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THE MARCH SCIENTIFIC MONTHLY

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THE SCIENTIFIC MONTHLY

MARCH, 1935

DEVELOPMENT OF CHEMICAL SYMBOLS

By Professor INGO W. D. HACKH

COLLEGE OF PHYSICIANS AND SURGEONS SCHOOL OF DENTISTRY, SAN FRANCISCO

THE development of chemical concepts is reflected in the history of chemical symbolism. Man has always tried to make pictures because visual instruction is most direct, and if pictures failed, he created symbols. Just as our alphabet[1] developed from picturegram to ideogram and ultimately to the phonogram, so the chemical symbols of to-day have undergone a development which may be traced to the Egyptian hieroglyphs.

A picturegram, such as a hieroglyph, can not be constructed for a chemical substance, because the appearance of any material substance is not sufficiently distinct. We may draw the picture of a hammer or saw, but we can not picture water, salt, gold or wine. Hence it is not surprising that the old Egyptians used the ideogram and later the phonogram for representing substances and materials. The hieroglyph for palm wine (Fig. 1) is of this nature and is a combination of a palm leaf and a jug; for wine in general (Figs. 2, 3), the first a phonogram *sha-t*, the later the conventional sign, consisting of two wine jars, presumably filled. Honey is depicted by a bee and a closed small jar (Fig. 4). The conventional hieroglyph (Fig. 5) for gold contains as its essential feature a symbol (Figs. 6 and 7) which in its older form (Fig. 6) is a cloth bag from which water runs. It is supposed to be held by both ends by two slaves who wash the gold from the river (the slaves are not shown, for their presence would mean the act of washing gold). There were several kinds of gold known to the Egyptians, *nub-en-mu* or river gold (Fig. 8) and *nub-en-set* or mountain gold (Fig. 9) which are characterized by the zigzag line indicating water (Fig. 22) and the three mountain peaks. Silver, closely allied to gold, has for its symbol (Fig. 10) *white metal* by imposing the ideogram *light* upon that of gold. Naturally occurring alloys of gold and silver (Fig. 11) *white gold*, is distinct from the *gilding of silver* (Fig. 12) or the hammering of gold upon silver objects, and its hieroglyph clearly indicates the human agency necessary. The third important metal, copper, is shown by a crucible (Figs. 13, 14, 15 and 16) which later becomes conventionalized to Fig. 17. Hieroglyph 13 is the *metal from the North*, and 14 the *metal from the South*, where the central bowl-like symbol designates metal, generally copper, and the luxurious plant of the moist Nile muds stands for north, as compared with the arid desert plant indicating south. In hieroglyph 18, *weapons made from copper*, we have an example of combining copper and spear.

The fact that iron and lead came at a later date is shown by their hieroglyphs, which are phonograms instead of ideograms. Thus Fig. 19 spells

[1] "History of the Alphabet," SCIENTIFIC MONTHLY, 25: 97–118, August, 1927.

PLATE 1. EGYPTIAN HIEROGLYPHS

1–3, WINE. 4, HONEY. 5–9, GOLD. 10, SILVER. 11, 12, SILVER-GOLD. 13–17, COPPER. 18, WEAPONS OF COPPER. 19, IRON. 20, LEAD. 21, NITRE. 22, WATER.

banpi, iron, for in this hieroglyph the pictures have a phonetic value. Fig. 20 means a *block of lead, nus,* in both of which the symbol for water (Fig. 22) has the phonetic sound *n.* Hieroglyph 21 stands for *netra* or *nitre,* to purify or cleanse by means of incense.

By various channels the hieratic and demotic characters of the Egyptians were borrowed by traders, officials and soldiers and spread north and west to the Baltic and Greece, south and east to Ethiopia, India and Mongolia. With the invention of phonetic writing it is not surprising to find that the Greeks and Romans had no symbols for chemical substances, for the written language was sufficient to express the idea. Thus *hydrargyros,* a combination of *hydor,* water, and *argyros,* silver, sufficiently identifies *water-silver* or mercury. No symbols are needed, when words suffice.

But with the rise of alchemy and the philosophical speculations implied thereby, symbolism flared up anew. The alchemists were inductive and speculative, the modern scientist is inductive and experimental. The alchemist first formed a concept of the universe surrounding him and then argued from his theory what the behavior of nature should be. Philo-

sophical speculation was in higher esteem than practical experimentation. Few alchemists stooped so low as to actually experiment, and those who did made history; as, Geber, Basil Valentine, Paracelsus, etc. In their writings it was customary to conceal rather than reveal facts, and for this purpose each respectable writer developed his own symbolism. This naturally made the writings more mysterious and difficult to understand and the reader had thus plenty of lee-way in speculating as to the meaning. Failure of transmutation or the non-appearance of the elixir of life and the philosopher's stone was merely due to misinterpretation of the symbols. Some of these symbols, shown in Plate 2, were used during the fifteenth, sixteenth and seventeenth centuries. The symbols for arsenic (Fig. 23) show various forms of the *dragon's head* or azimutal node sign as well as a cross and triple cross on account of its toxicity. Gold (Fig. 24) is always associated with the Sun or aurora; iron

PLATE 2. ALCHEMICAL SYMBOLS OF THE 15TH, 16TH AND 17TH CENTURIES, SHOWING THE ASSOCIATION OF ASTROLOGY AND ALCHEMY

23, ARSENIC. 24, GOLD. 25, IRON. 26, LEAD. 27, MERCURY. 28, SILVER. 29, SULFUR. 30, WATER.

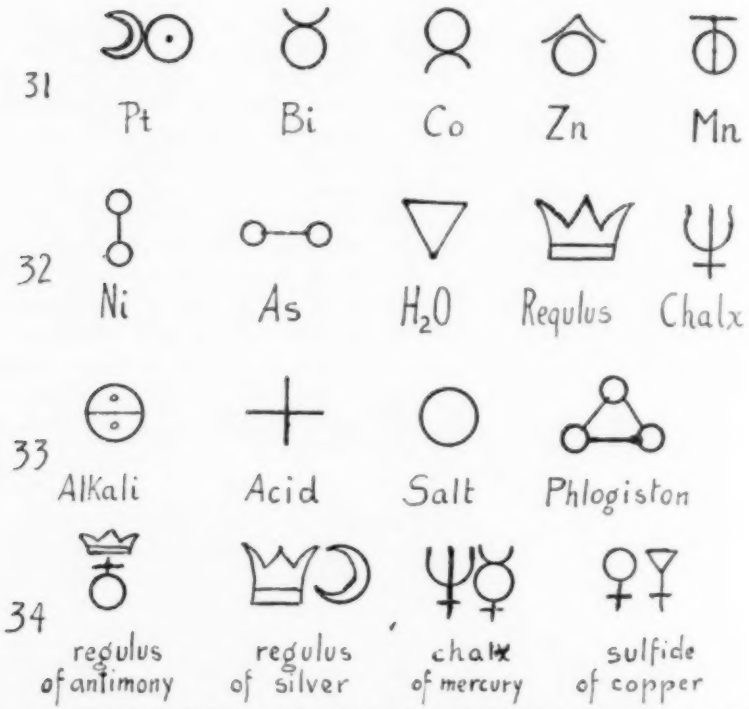

PLATE 3. BERGMAN SYMBOLS FROM HIS *OPUSCULA PHYSICA ET CHIMICA* (1783)

31, NEW DISCOVERED METALS. 32, 33, CONVENTIONALIZED SYMBOLS FOR CERTAIN CONCEPTS AND MATERIALS. 34, COMBINATION OF SYMBOLS.

(Fig. 25) with Mars, spears and weapons; lead (Fig. 26) with Saturn or on account of its poisonous nature with a double cross. Mercury (Fig. 27) is represented by the symbol of Mercurius in its various forms, as well as by a single cross. Silver (Fig. 28), next to gold (Sun), receives the next brightest celestial body, Moon, for its symbol; this association still survives in *lunar caustic*. Sulfur (Fig. 29) has a synthetic symbol resembling copper (venus) while water (Fig. 30) is either a triangle or a wave-line, curiously enough resembling the Egyptian hieroglyphic and the predecessor of the letter N or n.

The alchemistic symbols, however, became more and more conventionalized, hence toward the end of the seventeenth century certain symbols were universally used. In the *Pharmacopoeia Batanea,* compiled in 1694 by William Salmon, we find an emancipation from mystical allegories, for although the astronomical signs are preserved for the metals, they have no astrological meaning. Some of his symbols are:

☉ sol (Sun) or gold
☽ luna (Moon) or silver
♀ Venus or copper
♂ Mars or iron
♄ Saturn or lead
♁ Stibium or antimony
☿ Mercury or quicksilver
♃ Jupiter or tin
♋ arsenic
O alum
* sal ammoniac

In this list the symbol of antimony is listed also as *stibium* but not as *earth*.

The tenacious hold of astrology on alchemy is shown as late as 1781, when the planet Uranus was discovered and its symbol was given to platinum.

The next important step in symbolism may be traced in the writings of Torbern Olof Bergman (born March 20, 1735, in Katharinenburg (Westgothland) Sweden, died July 8, 1784). Bergman was professor of chemistry, physics, pharmacy and mineralogy at the University of Upsala and a prolific writer. Best known are his *Historia Chemiae medium seu obscurum aevum* (Upsala, 1782) and *De primordiis Chemiae* (Upsala, 1779). He describes the qualitative reactions of gold, platinum, silver, mercury, lead, copper, tin, bismuth, nickel, arsenic, antimony and manganese and gives accurate directions

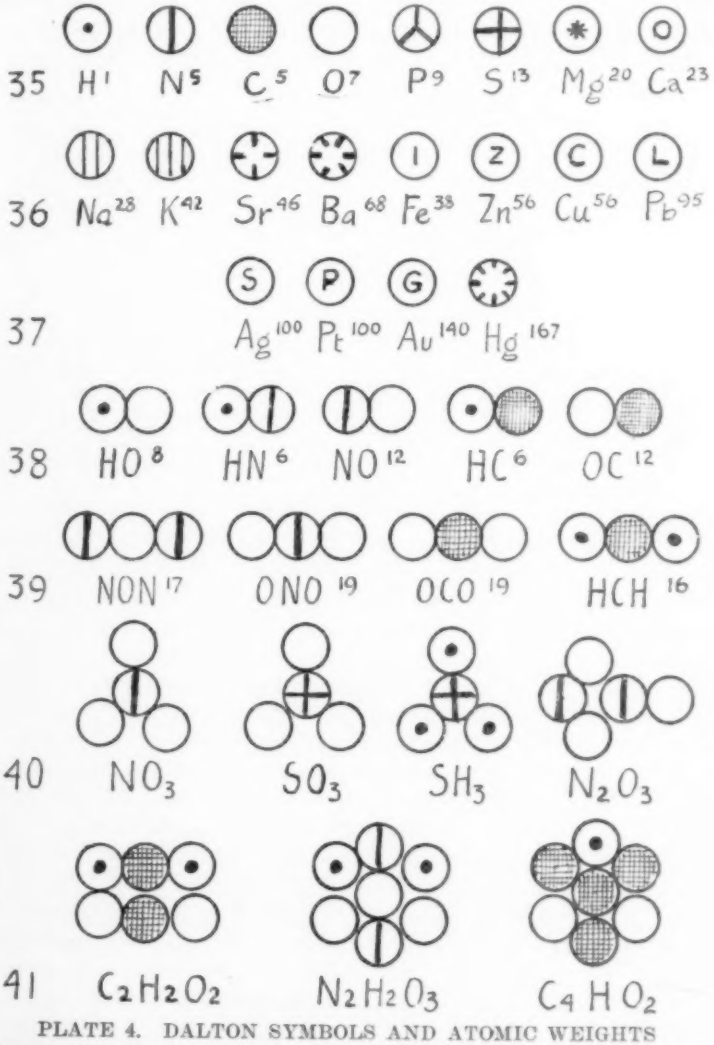

PLATE 4. DALTON SYMBOLS AND ATOMIC WEIGHTS

35–37, ELEMENTS. 38, BINARY COMPOUNDS. 39, TERTIARY COMPOUNDS. 40, QUATERNARY AND QUINQUENARY COMPOUNDS. 41, SEXTENARY AND SEPTENARY COMPOUNDS (ACETIC ACID, AMMONIUM NITRATE AND SUGAR).

for the analysis of ores containing these elements by means of hydrogen sulfide. In his writings he uses the customary astrological symbols for the metals; however, as he dealt with more metals than there were astronomic signs, he had to invent new ones. Some of these symbols are shown in Figs. 31, 32 and 33. For platinum, a noble metal, he chose a combination of the signs for gold and silver. He conventionalized the symbols for regulus (metallic globule), chalk (oxide or ash) and phlogiston, but more important he began combination of symbols (Fig. 34), which may be considered as containing the germ of the modern formula. Thus *regulus of antimony* or *regulus of silver* indicated the uncombined metal, but *chalk of mercury* was the oxide of mercury.

Into this atmosphere of symbolism was born John Dalton on September 5, 1766, at Eaglesfield, Cumberland, as the son of a poor weaver. He started his career in 1781 as apprentice teacher, then in 1785 with his brother headmaster of a school in Kendal and beginning in 1793 teacher of physics and mathematics in the New College of Manchester, where he died on July 27, 1844. In the year 1808 his classic "New System of Chemical Philosophy" was published, and thus the cornerstone for the law of multiple proportions and the atomic theory was laid. It is not surprising that Dalton used symbols for the atoms, all of them being circles having a different geometric design, and when the easily recognizable patterns were exhausted, the initial letter of the elements were used (Figs. 36 and 37). He thus paved the way for the Berzelius symbols, just as the Bergman symbols paved the way for him (Fig. 34).

The term molecule was unknown and thus Dalton classifies the compounds into binary atoms (Fig. 38), ternary (Fig. 39), quaternary, quinquenary (Fig. 40), sextenary and septenary atoms (Fig. 41). The starting point of his theory was the *light* and *heavy* hydrocarbon gas (methane and ethane), and as he used equivalent weights instead of atomic weights, his resulting formulas are not identical with the present ones. Thus water is described as "an atom of water or steam composed of 1 of oxygen and 1 of hydrogen, retained in physical contact by a strong affinity and supposed to be surrounded by a common atmosphere of heat" (Fig. 38). The other symbols are

Fig. 38: HO = water (H_2O)
NO = nitrous gas (NO_2)
OC = carbonic oxide (CO_2)
HN = ammonia (NH_3)
HC = olefiant gas (C_2H_4)

Fig. 39: NON = nitrous oxide (N_2O)
OCO = carbonic acid (H_2CO_3)
ONO = nitric acid (HNO_3)
HCH = marsh gas (CH_4)

Fig. 40: NO_3 = oxynitric acid (N_2O_4)
H_3S = sulfuretted hydrogen (H_2S)
SO_3 = sulfuric acid (H_2SO_4)
N_2O_3 = nitrous acid (NNO_2)

Fig. 41: $H_2C_2O_2$ = acetic acid ($C_2H_4O_2$)
C_4HO_2 = sugar ($C_6H_{12}O_6$)
$H_2N_2O_3$ = nitrate of ammonia (NH_4NO_3)

While during the lifetime of Bergman 14 new elements, including oxygen, nitrogen and hydrogen, were discovered, the life of Dalton witnessed the discovery of not less than 39 new elements. In the same period falls the beginning of modern chemistry, electrolysis, qualitative and quantitative analysis, and the names of Davy, Klaproth, Tennant, Vauquelin, Courtois, Wollaston and many others are well known, but Berzelius stands foremost.

Jöns Jakob Berzelius was born on August 29, 1779, in Wäfversunda (Eastgothland), Sweden, and died on August 7, 1848, in Stockholm. He first studied medicine, later chemistry in Upsala and Erlangen and in 1807 became professor of chemistry and pharmacy in Stockholm. A year after Berzelius began his duties Davy isolated calcium, magnesium and boron by elec-

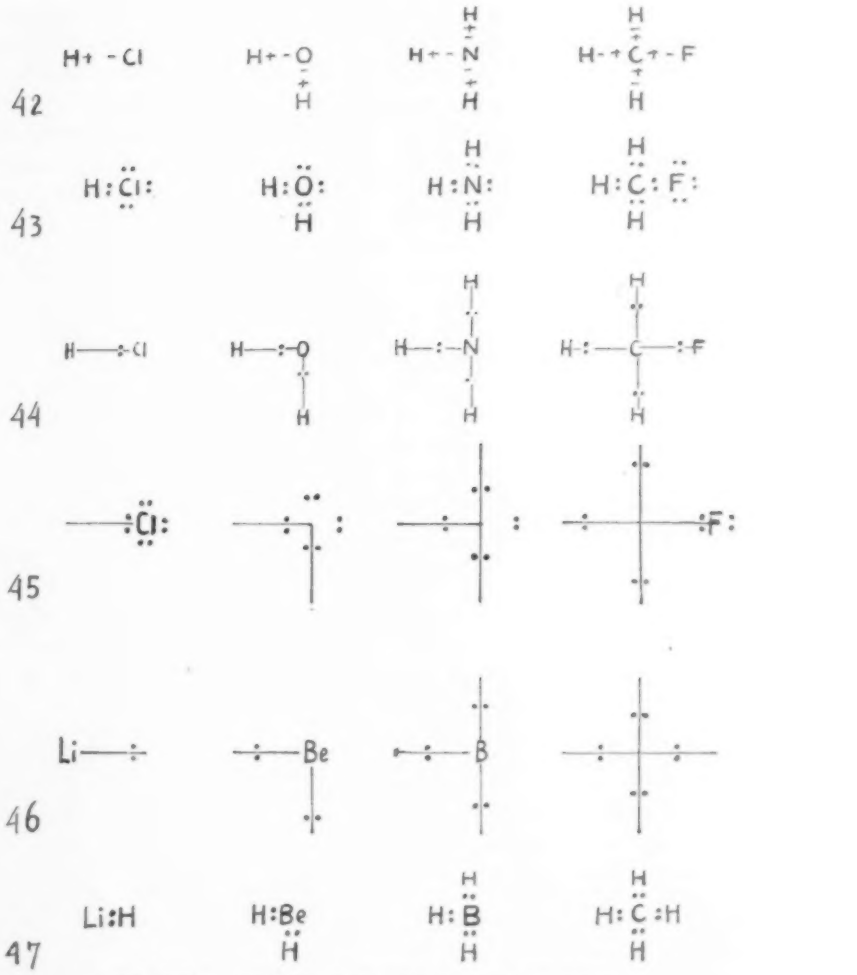

PLATE 5. ELECTROSTATIC OR POLAR BOND

42, BERZELIUS SYMBOLS OF ELECTROSTATIC AFFINITY. 43, 47, LEWIS OCTET FORMULA. 44, KHARASH POLARITY FORMULA. 45, 46, ELECTRONIC STRUCTURE SYMBOLS.

trolysis and thereby drew the attention of the chemical world to the electric forces residing in molecules. These led Berzelius in 1812 to conceive an electrostatic nature of the bond between the atoms; one atom was positive, the other negative. To express his ideas in the simplest manner, he substituted for Dalton's geometrical symbols the initial letter or letters of the element and thus initiated the modern notation. Small positive and negative signs indicated the electric nature of the atoms (Fig. 42).

POLAR BOND

The electrostatic bond of Berzelius has become the polar bond of Lewis, Kossel and others and is expressed in the Lewis octet formula (Figs. 43, 47) in which the valence electrons are pictured as dots. Thus in HCl the chlorine atom with seven electrons completes its octet by forming a pair with the single electron of hydrogen; when HCl is dis-

solved in water, it ionizes, that is, the chlorine atom retains the electron in its octet and has thus one negative charge, while the hydrogen, devoid of its electron, assumes a positive charge. There is a difference in the degree of this electrostatic or polar bond in different compounds, hence Kharasch and Reinmuth[2] developed a polarity formula (Fig. 44) which indicates the relative positiveness or negativeness of the atom by the distance of the electron pair from it. The electronic structure sym-

[2] *Jour. Chem. Ed.*, 5: 404–18, April, 1928; 8: 1703–48, September, 1931; and 11: 82–96, February, 1934.

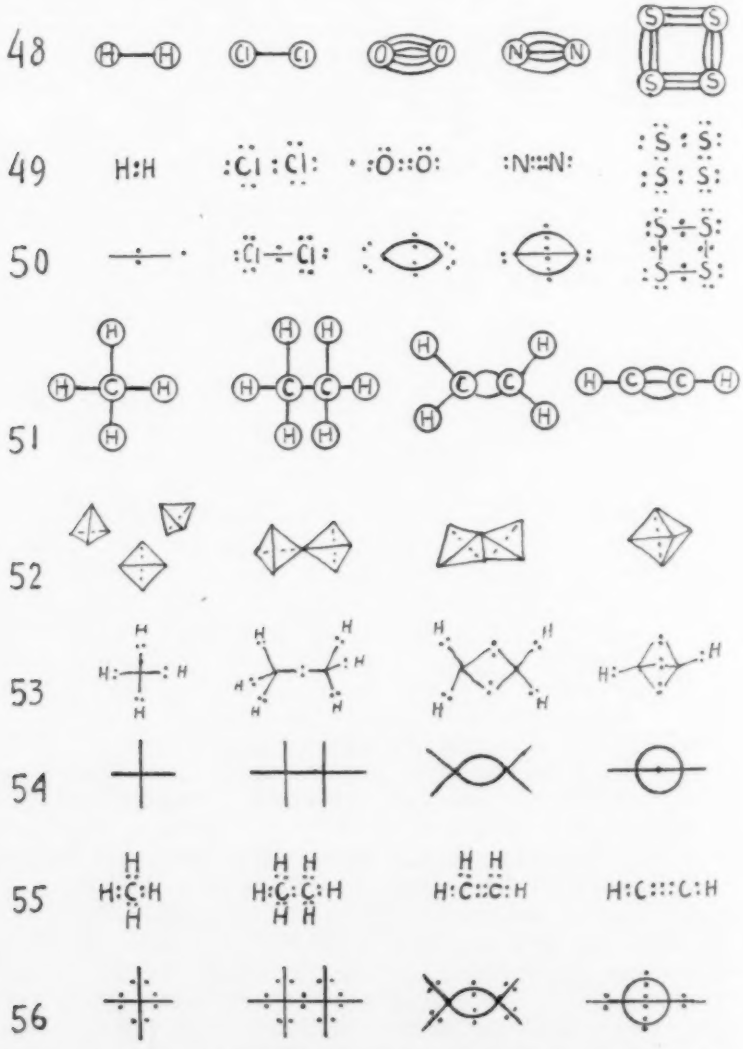

PLATE 6. GRAPHIC FORMULAS FOR THE NON-POLAR BOND

48, 51, GRAPHIC NOTATION OF KEKULE, FRANKLAND AND OTHERS. 49, 55, LEWIS OCTET FORMULAS. 50, 54, 56, STRUCTURE SYMBOLS. 52, TETRAHEDRAL CARBON ATOM OF VAN 'T HOFF, LEBEL AND WISLICENUS. 53, VECTOR SYMBOLS OF THE CARBON ATOM.

bols[3] (Figs. 45, 46) combine the advantages of the Lewis and Kharasch-Reinmuth notation by showing the polarity of the molecule by the position of the electron pairs. The more unshared electrons there are, as in Cl and O, the more negative the atom and the more polar the molecule, and *vice versa*. This is shown by a comparison of the hydrogen compounds of the elements of the first group of the periodic system; here the diameter of the octet increases steadily in passing from HCl to H_2O to NH_3 and CH_4. In Fig. 46 the hydrogen becomes less negative in going from LiH to BeH_2 to BH_3 and CH_4, which can be seen by drawing a line through the electron pairs of these respective compounds. In the case of methane, however, neither carbon nor hydrogen is negative or positive—the electron pair is located halfway between the atoms, both of which share them equally and constitute a non-polar bond.

Non-polar Bond

The synthesis of urea in 1828 by Friedrich Wöhler (1800–1882) marked the beginning of organic chemistry. The discovery that *organic* compounds can be made synthetically and without the aid of *vital* force led many chemists to investigate these interesting substances. It was only natural that many organic compounds were isolated which could not be explained by *electrostatic* bonds—the atoms were held together by some force upon which the electric current had no effect. Edward Frankland (1825–1899) and Adolph Wilhelm Hermann Kolbe (1818–1884) developed the theory of radicals during the middle part of the century and August Friedrich Kekulé (1829–1896) proposed the theory that carbon is tetravalent and has the greatest affinity for another carbon atom (1857), hence organic compounds are due to carbon-carbon bonds. In 1859 he proposed the ring structure for *hexamethin* (benzene) and thus laid the foundation for the study of aromatic compounds. The valences of carbon were shown by straight or curved lines as in the Frankland symbols (Figs. 48, 51) or the structure formulas of to-day, where we consider these bonds as non-polar or homopolar. This non-polar bond is shown in the electronic structure symbols (Figs. 50, 56) by placing the electron pair in the middle of the lines connecting the atoms.

Organic compounds, however, introduced the problem of isomerism, hence Jules A. Lebel (1847–18—) and Jacobus Hendricus van't Hoff (1852–1911) independently of each other considered the spacial arrangement of the tetrahedral carbon atom (1877). Ten years later (1887) Johannes Wislicenus (1835–1902) published his fundamental investigation on lactic acid which opened the field of optical isomerism and led to the geometrical formulas (Fig. 52). To project a space-model upon a plane surface involves difficulties, for many angles of perspective may be chosen. In Fig. 52 the carbon tetrahedron is shown respectively standing on one of its surfaces, its edges and its corner. It is the third projection which is assumed in structure symbols and represented by a cross (Fig. 54), where the horizontal arm would reach above the surface, the perpendicular arm be inclined below the paper surface. The single, double and triple C-C bond are also shown.

Instead of picturing the carbon atom as a tetrahedron the bonds may be thought of as vectors pointing from the center in the direction of the four corners of a tetrahedron. These vector formulas (Fig. 53) lead likewise to the electronic structure symbols (Fig. 56), where the non-polar bond is indicated

[3] Structure symbols are the structural formulas without the letters H, O, N and C, for as these elements have respectively a valency of 1, 2, 3 (or 5) and 4, they are indicated by points from which 1, 2, 3 (or 5) and 4 lines radiate. For bibliography see: Hackh, "Structure Symbols of Organic Compounds," vi, 139 pp., Philadelphia, P. Blakiston's Son and Co., 1931.

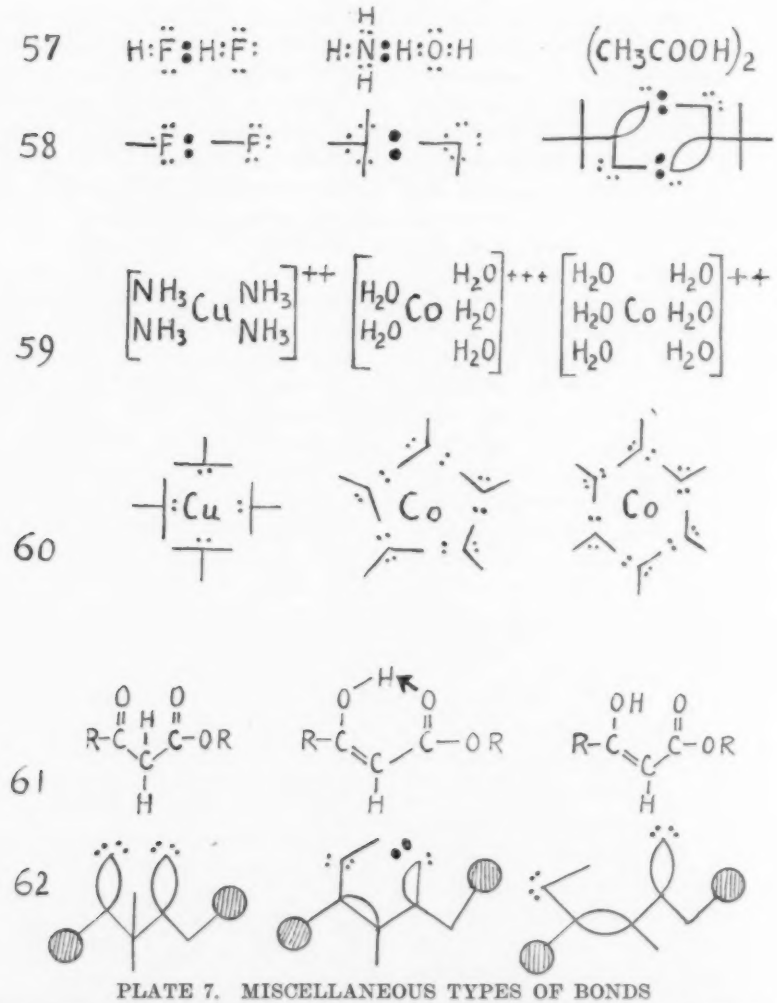

PLATE 7. MISCELLANEOUS TYPES OF BONDS

57, 58, ASSOCIATED MOLECULES. 59, 60, WERNER'S COORDINATE BOND FORMULA AND THE CORRESPONDING STRUCTURE SYMBOLS. 61, 62, SIDGWICK'S CHELATED COMPOUNDS AND THE CORRESPONDING STRUCTURE SYMBOLS.

by the electron pair being placed in the middle of each line.

Coordinate Bonds

Near the end of the century there were a number of facts known about the molecules which fitted neither the polar nor the non-polar type of bond. In 1900 Alfred Werner[4] (1866–1919) developed a theory of coordinate compounds and indicated these by the coordination formula (Fig. 59) which may be graphically depicted by the structure symbols (Fig. 60) where the water or ammonia molecules are *oriented* around the cobalt or copper atom.

Associated Molecules

So called *divalent* hydrogen resolves itself into a pair of oriented molecules where a hydrogen atom (in a very polar

[4] The portrait of Alfred Werner in the "Chemical Dictionary" (Blakiston's, Phila.) is erroneously labeled "Paul Sabatier," while Sabatier carries the legend "Alfred Werner."

compound) shares a free electron pair of a negative element. This coordinate bond is shown by the heavier dots in the Lewis symbols (Fig. 57) and the electronic structure symbols (Fig. 58). In the same class belongs the double molecule of acetic acid $(CH_3COOH)_2$, said to exist in aqueous solutions.

Chelated Bonds

The *chelated* compounds of Sidgwick[5] differ from associated molecules merely in having within *one* molecule the possibility of *divalent* hydrogen, that is, the possibility of the hydrogen sharing a free electron pair. Thus in the ketone-enol isomerism (Fig. 61) the position of the hydrogen, near two oxygen atoms, is such that it can alternately share the electron pair with the two oxygen or the carbon. The arrow indicates the *chelated* oxygen, while in the structure symbols (Fig. 62) the static and dynamic forms of ketone, ketone-alcohol and alcohol are shown.

Divided Valence

To indicate a *divided* bond, as in the –COOH group where the hydrogen is bound equally strong to *either* oxygen atom, it has been proposed to mark this by a dotted valence line (Fig. 63c). However, as this appears to be a dynamic isomerism, that is, a rapid oscillation of the electron pair or bond from position a to b to a, etc., the static structure symbol (Fig. 64) is either a or b, while the dynamic symbol is shown in c.

Abnormal Valence

Higher or lower valence than normal resolves itself into a coordinate bond. Thus the tetravalent oxygen in ester hydrochlorides (Fig. 65) is represented by the structure symbol (Fig. 66), where the heavy dots indicate the bond between the oxygen and the hydrogen of the oriented HCl molecule.

[5] Sidgwick, *Jour. Chem. Soc.*, 127: 907 (1925), "Electronic Theory of Valence," Oxford, 1927.

Benzene Ring

The structure of the benzene ring has occupied the attention of chemists ever since 1865, when Kekulé developed the common hexagon formula with three single and three double bonds between the six carbon atoms. But this static formula predicts that there should be two ortho, two meta and two para substitute compounds, whereas only one of each is known. Hence many attempts have been made to find a structure which makes the six carbon atoms equal to each other. Claus (1867) suggested a *diagonal* formula, resembling Fig. 67b, Ladenburg (1869) proposed the *prism* formula, Claus again (1870) the *bridge* formula, Armstrong and Baeyer (1892) a *centric* formula, where the fourth valence merely points toward the center of the ring, Thiele and others developed a *split valence* formula (Fig. 67a) and in more recent times Koerner developed a centroid arrangement of six tetrahedrons in alternately different planes. Pauling's *dynamic* formula conceives the electrons in elliptical orbits, and Huggins pictures three *oscillating* or shifting electron pairs in the center of the ring. The dynamic concept of the benzene ring is shown by the two structure symbols (Fig. 68) where the electrons are placed equally distant from all six carbon atoms, and it is thus immaterial from the position of the dots whether the double bond joins carbon 6 and 1, or carbon 1 and 2, etc. We may picture the benzene ring as constantly shifting between these two symbols, that is, an oscillating and rotating double bond, as illustrated by the mechanical benzene model.

Benzene Substitutions

If a negative or positive atom or radical substitutes one of the hydrogen atom of the benzene ring, an electron shift will occur, according to the electron formula of Lucas (Fig. 69) where the small rings indicate the electron

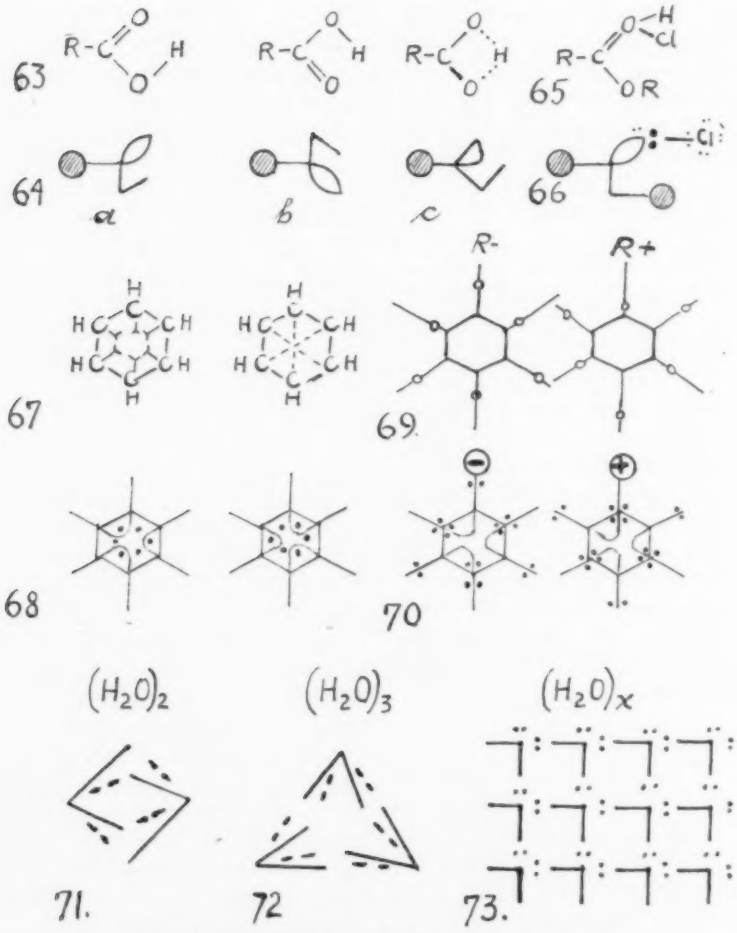

PLATE 8. MISCELLANEOUS NOTATIONS

63, 64, TAUTOMERISM OF THE –COOH GROUP WHICH ASSUMES A DIVIDED VALENCE FOR THE H-ATOM. 65, 66, TETRAVALENCE OF OXYGEN IN ESTERS WHERE THE KETO-OXYGEN IS ASSUMED TO FORM AN ADDITION COMPOUND WITH HCl. 67, 68, VARIOUS FORMS OF THE BENZENE RING. 69, 70, LUCAS POLARITY FORMULA AND THE CORRESPONDING STRUCTURE SYMBOLS FOR SUBSTITUTED BENZENE RING. 71, 72, STRUCTURE SYMBOL FOR DIHYDROL AND TRIHYDROL. 73, STRUCTURE SYMBOL FOR THE SPACE LATTICE OF ICE.

pair. Thus a negative atom or radical pulls the electron pair from carbon 1, which thus becomes positive. This results in carbons 2 and 6 as well as 4 becoming negative; while 3 and 5 become negative. Should the radical be positive, the reverse polarization takes place. The corresponding structure symbols are shown in Fig. 70.

WATER AND ICE

According to its temperature, water consists of varying percentages of monohydrol, H_2O; dihydrol, $(H_2O)_2$, and trihydrol, $(H_2O)_3$. Cold water has more trihydrol, hot water more monohydrol, the dihydrol present in approximately 50 per cent. These two associ-

ated molecules are shown in Figs. 71 and 72, where each hydrogen is held also by a coordinate bond to another molecule; it shares the free electron pair of the oxygen of its opposing molecule. (The electron pairs have been elongated in the symbol to show direction.)

Ice has a crystal lattice of an oxygen atom surrounded by four hydrogen atoms. This space lattice is shown on a plane surface by structure symbol 73, where only the free electron pairs are (conventionally) shown. To make the picture complete, it must be considered dynamic, that is, the lines indicating the H-O bonds will swing around, as the hydrogen and oxygen kernels oscillate or wiggle, according to their temperature, until they finally melt and form trihydrol and dihydrol associations.

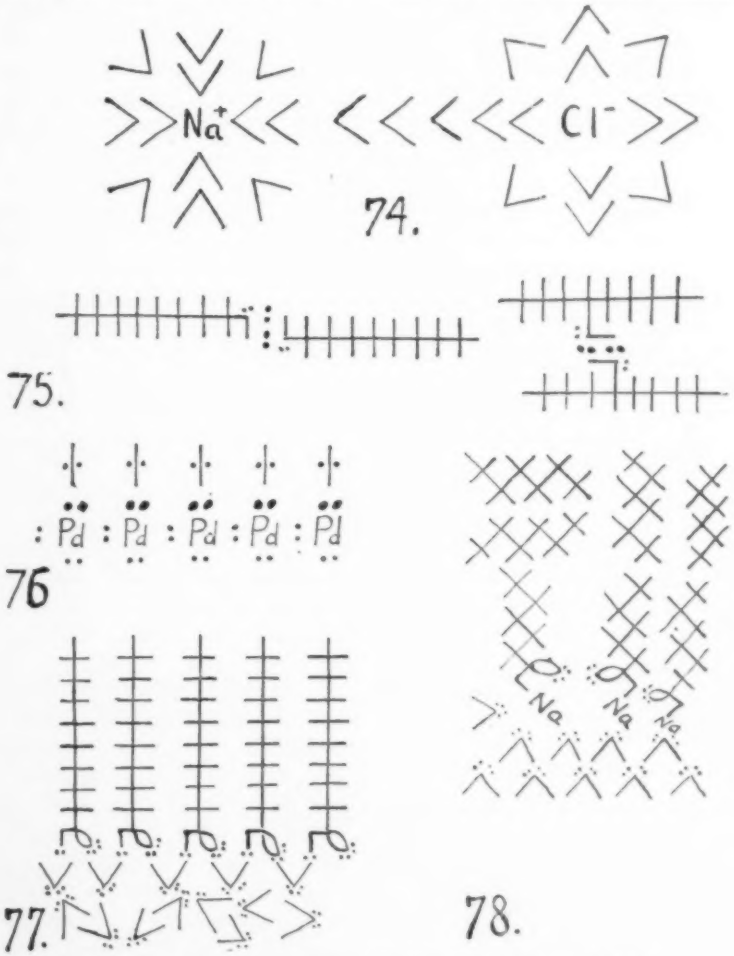

PLATE 9. VARIOUS USES OF STRUCTURE SYMBOLS

74, SOLVATED IONS WITH ORIENTED WATER MOLECULES. 75, CYBOTAXIS OR LENGTHWISE AND SIDEWISE ASSOCIATION OF TWO OCTANOL MOLECULES (1-HYDROXY- AND 4-HYDROXY-OCTANE, RESPECTIVELY). 76, ADSORPTION OF H_2 MOLECULES ON A PALLADIUM SURFACE. 77, ORIENTATION OF FATTY ACID MOLECULES ON WATER SURFACE. 78, SECTION THROUGH A COLLOID: HEXANE-SOAP-WATER.

Solvation and Ionization

When a polar compound like NaCl is dissolved in water it ionizes and forms Na^+ and Cl^- ions. The more negative or positive the elements, the higher the degree of dissociation. This can be visualized by structure symbol 74, which shows that the water molecules are oriented around the sodium or chlorine kernels; the oxygen of the water points toward the positive ion, while the hydrogen points toward the negative ion. Such layers of oriented molecules probably act as buffers, and the entire group moves as a particle or micelle through the water.

Surface Adsorption

If hydrogen gas is brought in contact with a palladium or platinum surface the electron layer of the metal will attract the hydrogen molecules, and these will orient themselves upon the metal surface as shown in Fig. 76. The hydrogen condenses practically to a solid, thereby liberating heat (which has been utilized in Doebereiner's fire machine and the modern gas lighters using platinized asbestos).

Monomolecular Films

A layer of a fatty acid upon water is shown in Fig. 77, where the polar –COOH groups dip into the water, while the non-polar hydrocarbon ends of the fatty acid point away.

Cybotaxis

Cybotaxis is the oriented association of similar molecules; thus 1-octanol arranges itself lengthwise (Fig. 75), while 4-octanol is oriented sidewise.

Colloids

Orientation likewise plays a large rôle in colloidal systems; thus a cross-section through the boundary between hydrocarbon-soap-water is shown in Fig. 78. The non-polar hydrocarbon is a normal or non-associated liquid which possesses no *unshared* electron pairs, while water is a highly polar or associated liquid, having many unshared electron pairs. Between these two liquids the molecules of the protective colloid arrange themselves so that their polar end points into the polar liquid (water), their non-polar end into the non-polar liquid (hydrocarbon).

Free Radicals

A free radical is indicated in the Lewis notation by an unfinished octet, thus tri-R-methane or di-R-nitrogen lack both one electron to complete the octet (Fig. 79) and the corresponding structure symbols (Fig. 80) show the single electron as a heavier dot on a dotted line. The dotted line is the conventional indication of the valence bonds necessary to show a particular atom, four lines for carbon, three for nitrogen, etc. If the line were solid it would indicate a hydrogen atom at the end of it.

Active Compounds

Some molecules may exist in an active and inactive form; thus for formaldehyde there are assumed the two types shown in Figs. 81 and 82, where the active form is indicated by the two single electrons; the aldehyde structure has become an alcohol structure. The dotted line indicates the free valence.

Addition Compounds

Coordinated and associated molecules as well as the solvated ions may be considered as addition compounds of varying degree. In each case the positive atom (without free or unshared electrons) shares the electron pair supplied by a negative atom. An example of an organic addition compound is boron trichloride di-R-oxide (Figs. 83, 84), which according to the older concept requires tetravalent boron and trivalent oxygen, but which reveals itself as an oriented molecule in which the positive boron shares the electron pair of the oxygen atom, as shown in structure sym-

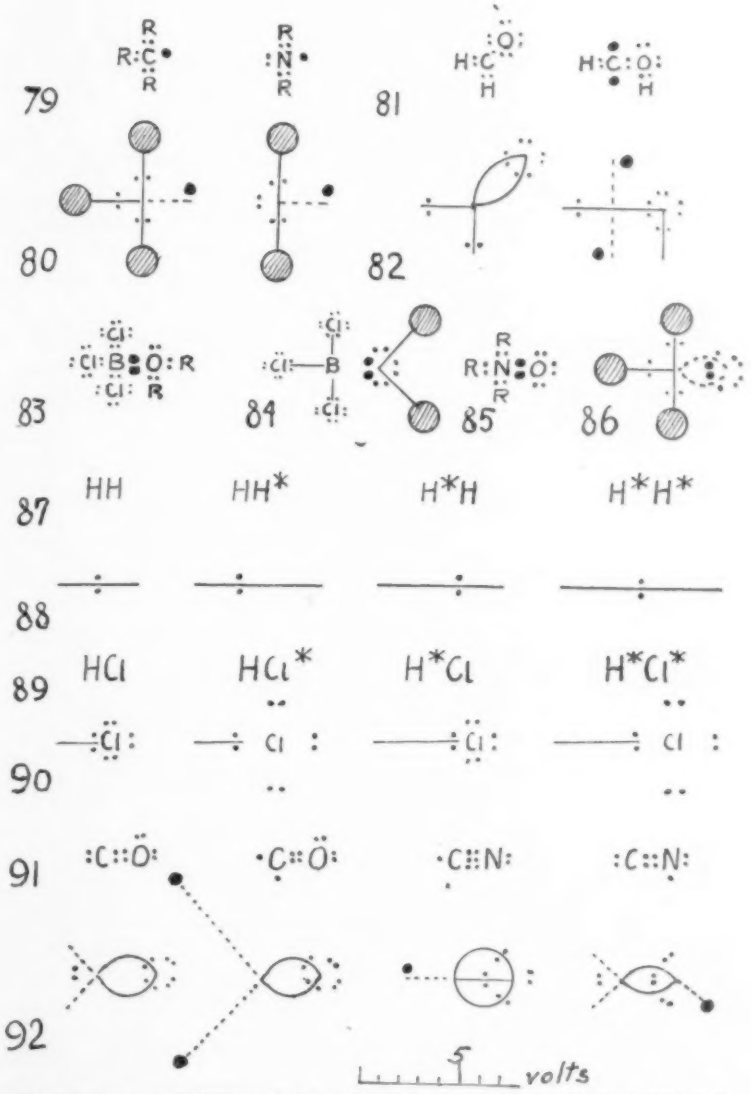

PLATE 10. OTHER APPLICATIONS OF STRUCTURE SYMBOLS

79, 80, FREE RADICALS: TRI-R-METHANE AND DI-R-NITROGEN. 81, 82, INACTIVE AND ACTIVE COMPOUNDS: FORMALDEHYDE. 83, 84, ADDITION COMPOUNDS: TRICHLOROBORON DI-R-OXIDE. 85, 86, TRI-R-AMINE-OXIDE. 87, 88, EXCITATION: HYDROGEN MOLECULE. 89, 90, EXCITATION: HYDROCHLORIC ACID. 91, 92, NORMAL AND EXCITED MOLECULES: CO AND CN.

bol 84. Similar is the structure of amine oxides (Figs. 85, 86), where nitrogen shares the free electron pair of an oxygen atom.

Excitation and Irradiation

Atoms or molecules may absorb certain quanta of light energy and become excited, that is, their electrons move in higher energy levels. Excited atoms are indicated in the ordinary formula by an asterisk (*), as in Figs. 87 and 89, while in structure symbols the length of the lines or the size of the electron octet

may show the state of excitation (Figs. 88 and 90). If more definite information is known as to the distribution of the electrons in the normal and excited state, the structure symbols may be used as energy diagrams (Fig. 92). Thus Pauling[6] determines for the normal and excited state of CO and CN the electron distribution shown by the Lewis symbols (Fig. 91) and an energy difference of 5.96 and 1.78 volts, respectively. These changes are graphically shown in Fig. 92, where the distance of the electron from the atom is proportional to the force. In the CN radical a shift of an electron pair occurs.

[6] Pauling, *Jour. Amer. Chem. Soc.*, 53: 1367, 1931.

Isotopic Compounds

The discovery of heavy hydrogen (deuterium, diplogen, *b*-hydrogen, H^2 or H^b), together with the oxygen isotopes, gives nine possible water molecules (Figs. 93 and 94), which have among several other proposed names the following:

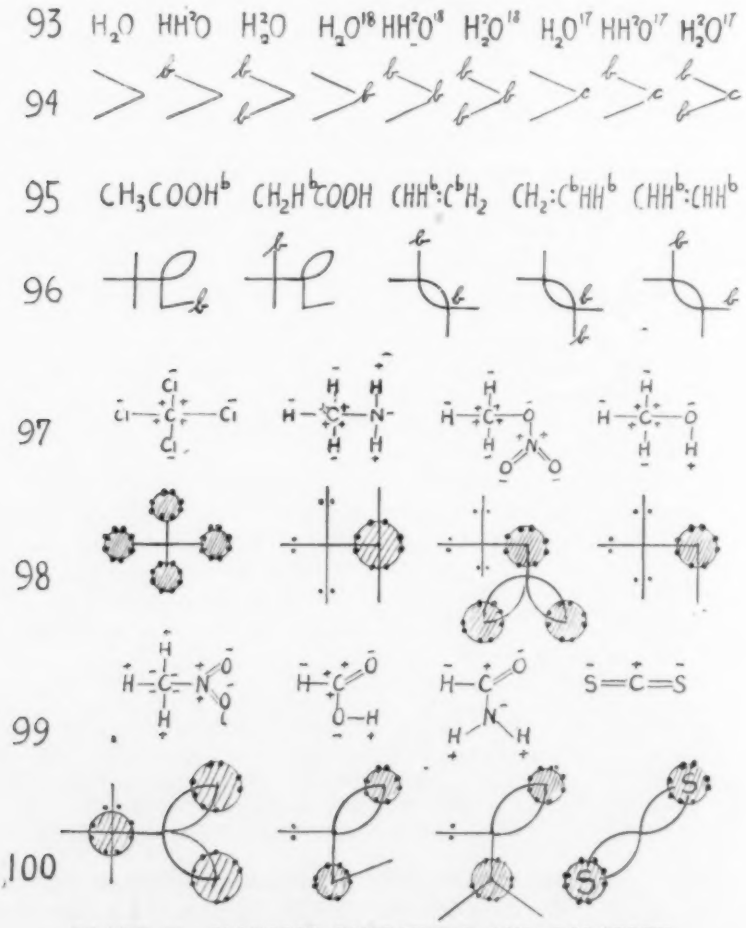

PLATE 11. ISOTOPIC COMPOUNDS AND POLARITY

93, 94, ISOTOPES OF WATER. 95, 96, ISOTOPIC COMPOUNDS: TYPES OF ACETIC ACID AND ETHYLENE. 97, 99, POLARITY FORMULAS. 98, 100, STRUCTURE SYMBOL DIAGRAMS FOR ELECTRICALLY SYMMETRIC AND ASYMMETRIC COMPOUNDS. (NEGATIVE AREA IS SHADED.) DIELECTRIC CONSTANT INCREASES FROM CCl_4 TO $HCONH_2$.

	Proposed Name[7]
diprotium oxide	hydrogen oxide
mono-deuterium oxide	*b*-hydrogen oxide
di-deuterium oxide	*bb*-hydrogen oxide
diprotium heptadecanide	hydrogen-*b*-oxide
mono-deuterium heptadecanide	*b*-hydrogen-*b*-oxide
di-deuterium heptadecanide	*bb*-hydrogen-*b*-oxide
diprotium octodecanide	hydrogen-*c*-oxide
mono-deuterium octodecanide	*b*-hydrogen-*c*-oxide
di-deuterium octodecanide	*bb*-hydrogen-*c*-oxide

The apparently limitless possibilities of isotopic compounds in organic chemistry is indicated by the fact that there are possible 288 different acetic acids or 20, 968, 879, 178, 648 normal stearic acids, with two isotopes of hydrogen, two of carbon and three of oxygen. Thus with the two hydrogen isotopes alone there are the following eight acetic acids:

CH_3COOH CH_2H^bCOOH CHH^b_2COOH CH^b_3COOH

CH_3COOH^b $CH_2H^bCOOH^b$ $CHH^b_2COOH^b$ $CH^b_3COOH^b$

The terminology of these isotopic compounds will be so complex that their formulas (Figs. 95, 96) apparently are the simplest means of identification. In the case of ethylene, $CHH^b:CHH^b$, there should exist a cis- as well as trans-isotopic form.

Dielectric Constant

The specific inductive capacity of a liquid depends upon the electrical symmetry of the molecules composing it. If the negative charges are symmetrically located in space and equally distributed in respect to the positive charges, the dielectric constant is low, as in CCl_4 or CS_2. If one or more chlorine atoms of CCl_4 are replaced by hydrogen, the molecule becomes electrically asymmetric, for the negative charges (chlorine atoms) are unevenly distributed on the corners of a tetrahedron. The greater this asymmetry, the higher the dielectric constant. The polarity formulas (Figs. 97, 99) are arranged so that from CCl_4 to $H \cdot CO \cdot NH_2$ the dielectric constant increases, hence these compounds show an increasing electric asymmetry. In the structure symbols (Figs. 98, 100) this increasing electric asymmetry is shown by shading the negative areas. Projecting these symbols into three dimensions will naturally show the electrical symmetry conditions to better advantage, for in the case of $H \cdot CO \cdot OH$ the two oxygens are in one plane, or on two corners of the tetrahedron, which makes thus the molecule lop-sided.

Polarization

While the polarity formula indicates the dipole nature of the molecule, that is, the distribution of electrical charges within the molecule, the polarization formula shows the changes within the molecule in respect to its surrounding. Thus, in the case of water, where the distance of hydrogen to oxygen is 0.96 ångstrom units and the angle of hydrogen-oxygen-hydrogen is 105° (Fig. 101), an electric field may distort and displace the atoms as follows:

Electronic polarization, where the electrons are displaced with respect to the positive nucleus, as in 102a.

Atomic polarization, where the atoms are displaced, or the molecule is distorted, as in 102b.

Molecular polarization, or orientation of the molecule, as in 102c. In Fig. 102d, e and f, a combination of these three types of polarization is shown.

Isosteres and Electronic Constellations

Isosteres are sets of compounds with similar electronic constellation, that is,

[7] Following the suggestion of *Terminologist* in naming isotopic compounds: *Science*, 79: 505, June 1, 1934.

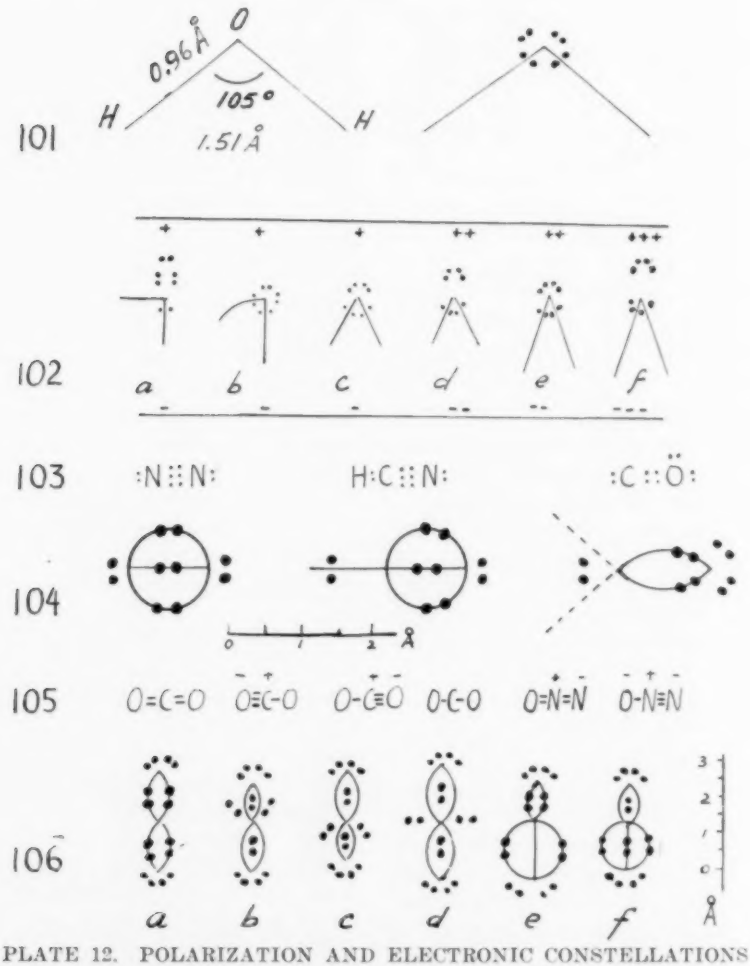

PLATE 12. POLARIZATION AND ELECTRONIC CONSTELLATIONS

101, WATER MOLECULE DRAWN TO SCALE. 102, POLARIZATION: A, ELECTRON DISPLACEMENT; B, ATOM DISPLACEMENT; C, MOLECULE DISPLACEMENT (ORIENTATION); D, E, F, COMBINATIONS. 103, 104, ELECTRONIC CONSTELLATIONS: THE ISOSTERES OF NITROGEN, HYDROCYANIC ACID AND CARBON MONOXIDE. 105, 106, ELECTRONIC CONSTELLATIONS: THE SHIFTING ELECTRON PAIRS OF CARBON DIOXIDE AND NITROUS OXIDE.

similar configuration of the electrons. Thus nitrogen, hydrocyanic acid and carbon monoxide have each ten electrons (Figs. 103 and 104) and similar physical and biological properties. Their molecules are drawn to scale in the structure symbols 104, where the similarity of HCN and CO is indicated by the octet and single pair of electrons.

In the case of carbon dioxide and nitrous oxide there are, according to Pauling, various electronic constellations possible, which probably all exist and form in rapid succession. As the atomic kernels oscillate, the electrons shift. Thus the distance of the C=O bond is 1.28 ångstroms, that of the C ≡ O 1.13 å. The alternate shortening

and lengthening of the distance between the atomic nuclei causes the electron pairs moving from positions shown in 106a, b, c and d, for carbon dioxide, and a similar number of positions for nitrous oxide, of which only two, Figs. 106e and f, are shown. It will be noticed that a and e, as well as c and f, are similar constellations.

Summary

The evolution of the chemical symbols is an interesting chapter of chemistry and illustrates the attempts of the human mind to represent its concept of facts and fancy in a concise and generally pictorial way. Beginning with the ideogrammatic hieroglyphs it has passed through the allegorical symbolism of the alchemists and emerged into the simple notation of to-day.

The newer developments in physical and organic chemistry make it again desirable to use graphs and diagrams of the molecule. Structure symbols provide a simple means of showing qualitative (as diagram) or quantitative (as graph) the different types of bonds between the atoms, polarity and polarization, orientation, colloidal structures, atomic distances and electronic constellations, besides the more familiar structural relationships, as isomerism and the possible future compounds of isotopic carbon, hydrogen and oxygen.

In unifying the concept of atomic bonds the electronic structure symbols illustrate the three fundamental types of bonds as:

(1) *Ionizing* or *polar* bond (where the electron pair is held unequally; one atom becomes more negative, the other more positive)—by a pair of dots astride a line and displaced toward the negative end of a line;

(2) *Non-ionizing* or *homopolar* bond (where the electron pair is shared equally, neither atom becomes positive or negative)—by having a pair of dots astride a line and halfway between the end of the line indicating the bond; and

(3) *Coordinate* or *semipolar* bond (where a negative atom contributes both electrons which are shared, more or less firmly, by a positive atom)—by a pair of dots without a line indicating the bond.

BIOLOGICAL APPROACHES TO ANTHROPOLOGY

By Dr. LELAND W. PARR

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ANTHROPOLOGY has developed through the study of such racial features as art and architecture, folk-lore, language and literature, religious beliefs and practises, work, play, social customs and warfare. To this has been added information gained from exact anatomical measurements. Recently certain biological sciences, other than anatomy, have contributed to the study of man, notably physiology, pathology and immunology. A brief review follows of certain data from these fields, and if more than a due share derives from work done in the Near East the explanation is the writer's former residence in that area.

In theory racial peculiarities are of two kinds. There are first those which result from environment. These any folk group might be expected ultimately to take on when confronted with the given environment. Secondly, are racial features based on fundamental genetic structure, which exist irrespective of wind, tide, temperature, rainfall, altitude or other environmental factors or combinations thereof. In practise the distinction is not always sharply to be made. Needless to say, racial features based on essential genetic structure are more useful to the anthropologist in tracing origins, migrations and relationships than those acquired in a given environment, possibly to be lost when that environment no longer exists.

The points first to be discussed partake somewhat of the nature of the first category. Of these, we list basal metabolism, vital capacity, blood pressure, pulse rate, visual and auditory acuity, muscular strength, age of onset of puberty and climacteric, dental conditions and various aspects of racial pathology.

Basal metabolism is an individual's minimal heat production measured fourteen to eighteen hours after eating, while at complete rest but not asleep. It represents energy expended to maintain respiration, circulation, peristalsis, muscle tonus, body temperature, glandular activity and other vegetative functions. It is measured with a calorimeter and its value is expressed in calories per hour per square meter of body surface. Certain standards have been set up as normal, such as those of Sanborn, of Harris and Benedict, of Dreyer and of Aub and Du Bois. An average value for basal metabolism is 40 calories per hour per square meter of surface. In racial studies it is customary to express the deviation from the normal in plus or minus percentages rather than to state the exact metabolism. Thus Heinbecker reported a + 33 per cent. metabolism for Eskimos; Steggerda and Benedict a three-day average of + 8.4 per cent. for male Maya Indians in Yucatan; Mason and Benedict a value of – 17.2 per cent. for 54 women from South India, and Krishnan and Vareed somewhat similar low figures for women medical students at Madras. Nearly fifty papers on basal metabolism in different ethnic groups have been published. It will suffice to point out that with the exception of the Yucatan Maya Indians, groups living in tropical or subtropical areas show a lower basal metabolism than do white Westerners. It is well recognized that basal metabolism varies with age, sex and state of health. Type of diet may be a factor as in the Bengali, whose food is low in protein, fat and satisfactory vitamin and mineral content. Perhaps the generally low metabolic rate of the

Oriental derives from the fact that in rest his relaxation is more complete than that of the Occidental. Possibly the psychology of a fatalistic or other worldly people has something to do with it. Some writers have implicated the climate per se as a factor. Benedict, however, than whom none can speak more authoritatively, feels the different basal metabolism values obtained carry a racial factor.

In the Near East basal metabolism studies have been made by Turner at Beirut. He found the metabolic rate for Armenian males to approximate Aub and Du Bois' standards. This is just what one would expect, for the Armenian is Balkan rather than Asiatic. The lowest values Turner obtained in his first series on males were from Egyptians. The Arabic-speaking Syrian was below accepted standards but rated above the Egyptians. As illustrating the fundamental nature of the metabolic function two of Turner's controls were Americans of the second generation in the Syrian climate. This recalls Benedict's work with low metabolism Chinese and Japanese girls in America and the work of Blunt and Dye with a Japanese woman living under American conditions yet retaining her −14 per cent. Japanese metabolism.

Turner, assisted by Dr. Adma Aboushadid, found an average value of −13.3 per cent. for 24 of 28 Syrian girls typical of their race and higher values for one girl who was half English and for three whose physical appearance suggested European rather than Syrian antecedents. It is true that in this series the control group of women, American and European personnel, was somewhat below normal, but there was, notwithstanding, a marked difference between them and the twenty-four Syrian girls. Turner has recently affirmed his belief that the Syrian basal metabolism is 8 to 12 per cent. below accepted standards. He is inclined to feel that the possibility of a more complete relaxation is important in the explanation. The fact retains its value for racial characterization, even so.

Vital capacity refers to the number of cubic inches of air one can forcibly expire after a full inspiration. Texts put this at about 3,700 cc for the average adult white male. In America distinct vital capacity differences between whites and blacks have been noted by Wilson and Edwards, by Smillie and Augustine and by Roberts and Crabtree. The vital capacity of the Negro race in both sexes and at all ages studied is remarkably lower than that of the white. Studies on Chinese, Siamese, Filipinos and natives of India show likewise low vital capacity rates. Turner found Syrian vital capacity to be below standard. It is interesting to note that Schneider confirmed the belief of physiologists that lowering of the barometric pressure temporarily reduces vital capacity. Most of the folk groups with lowered vital capacity live at as high barometric pressure as do American whites. This is particularly true for Turner's groups, practically all of whom resided on the Syrian coast.

Blood pressure refers to the tension in the walls of the blood vessels occasioned by pulsations of the heart. Diastolic pressure is the pressure in millimeters of mercury in the brachial artery during diastole, which is the stage of dilation of the heart, especially of the ventricles. Systolic pressure, obviously greater than diastolic, is the pressure in the artery during systole or contraction of the ventricles which occurs at the time of the first heart sound as the blood is driven into the great aorta and the pulmonary artery. Diehl at Minnesota found a definite gradation in blood pressure from Filipinos, Chinese and Japanese up through Negroes to Americans and Scandinavians. Roddis and Cooper studied army officers under tropical and temperate zone conditions of residence

and concluded that low blood pressure in the tropics is primarily due to altered physical activity. This point is supported by the survey of a prison population of 6,400 by Alvarez and Stanley, who noted failure of blood pressure findings to show changes with age anticipated in the usual normal population. Turner states that Syrian blood pressure probably averages slightly lower than that for American whites, but he is not inclined to give much weight to this difference. It is, however, significant that diseases of high blood pressure are not as common among natives of low blood pressure areas as elsewhere, although in those areas persons of other races may and do exhibit hypertension.

Another physiological feature more easily determined but much harder to interpret racially is pulse rate. Syrian pulse rate is said by Turner to be practically normal. Hrdlička states that slow pulse rate is an Indian characteristic, and it has been particularly called to our attention in the high basal metabolism Yucatan Mayas that their pulse rate is low.

Bunch and Raiford have studied auditory acuity among whites and blacks in the United States. They noted certain differences. Such studies should be extended and might well include visual acuity, apart from color vision. Lefrou reports that blacks of Equatorial Africa are less vividly impressed by the light used in ophthalmoscopic examination and can fix their attention on points in space with less fatigue than can whites. He tells of laboratory aides who diagnosed relapsing fever spirochetes in fresh blood preparations under powers of the microscope which revealed absolutely nothing to him and his European colleagues. He was of opinion that this was because of a better appreciation of the movement of particles rather than a question of unusual powers of vision, although he does make incidental reference to some fundamental racial eye structure differences, a point which should be checked.

It is common knowledge that the onset of puberty and the climacteric are physiological factors which vary under different conditions of race and environment. In some tropical countries early marriages, at which we are so shocked, derive their local sanction from the early onset of puberty and the belief amongst the people that child-bearing should begin shortly after the sexual functions are established. One standard text states: "Heredity is also a determining factor, and experience demonstrates that girls of Latin extraction develop into womanhood earlier than those of Anglo-Saxon descent." Limits for the average onset of menstruation as commonly set vary from nine years in the tropics to sixteen or seventeen years in the north. The justice of nature to the individual woman is hard to understand when we realize that, all else being equal, early menstruation means late menopause, although the working out of this order of things on the whole is rational, with mass production and destruction in the tropics and lessened production and destruction in the north.

Conditions of the teeth have long been noted as racial characteristics and believed by many to have some inherent genetic background. Teeth are, of course, much influenced by nutrition and other environmental factors. The excellence of the teeth of many peasant peoples of Africa and Asia is as well known as the defectiveness of the English teeth is notorious.

In an interesting comment on anthropology and medicine in one of the older Systems of Medicine, Beddoe points out that by analogy with animals different races of men should present quite different pictures of pathology. Before it was known that many diseases were communicable and caused by parasite, bacterium or virus, many very striking racial disease peculiarities were recorded.

With the advent of the concept of the direct or indirect microbic etiology of most of our important diseases emphasis on racial differences in disease has been transferred from man's racial contribution to the microbes' geographical distribution. Probably it would be wiser to include both man and microbe in such considerations.

In the light of the recent development of knowledge concerning bacterial variation, we are now more than ever in position to understand that disease incited by living agents is variable. A change in type in a given disease can in some instances be observed within a lifetime (*cf.* scarlet fever) and while there is more or less of cyclic nature to rises and falls of virulence, to epidemics and to absence of epidemics, it seems true that a given disease as studied by one generation will differ somewhat from that seen by another. If we can determine foci of antiquity for a disease, as contrasted with areas where it is new, differences will be observed in the way it attacks people, which should interest the anthropologist. That these matters are not easy to decide is well illustrated by the controversy of syphilologists as to whether syphilis existed in American Indians before Columbus' time, whether yaws is syphilis and whether the pandemic "bejel" of the Arab, as reported by Ellis Hudson, is syphilis.

A classical example of the difference between the action of a disease new to an area and one old to it is afforded by tuberculosis. We measure the extent of tubercularization of a race by the type of tuberculosis it has and by the percentage of tuberculin reactors present in the population. The tuberculin reaction elicits a positive reaction in those with sensitization to the tubercle. The number of positive results varies from nearly zero in natives of the Sudan and similar primitive peoples to 100 per cent. in adults of the working classes in such a place as Oslo (Heimbeck). Goodale and Krischner examined 944 Syrians and Armenians at Beirut and found only 47.6 per cent. tuberculin positive. At Beirut, also, Goodale analyzed 1,150 cases of tuberculosis and found that the non-pulmonary type (bone and joint tuberculosis, particularly) exceeded the pulmonary types by 738 cases to 412. The Near Easterners are then midway between the primitive and the race-adult type of tuberculosis.

It is quite impossible here to enumerate the numerous very interesting examples of the racial aspects of disease. Racial pathology is being developed extensively in Europe under Askanazy and in America, particularly in its tropical diseases aspect by a committee of the National Research Council directed by McKinley. It will suffice here to insist that this material, usually considered only of interest to medical men, has much in it of value for the anthropologist and to include one or two more references to the Near East.

The scarcity of diphtheria, and particularly scarlet fever, in warm countries has been remarked by many observers and is quite in contrast to the universal distribution of measles. Oddly, not only are these diseases uncommon in those areas but susceptibility to them is low. The Dick test presumably reveals susceptibility to scarlet fever. Parr, Goodale and Krischner applied it to 714 Near Easterners at Beirut and found but 6.4 per cent. positive or susceptible to scarlet fever, whereas of 38 Anglo-Americans tested at the same time 57.8 per cent. were positive. The Schick test reveals susceptibility to diphtheria. It was applied at Beirut by Parr, Goodale and Krischner to 878 local inhabitants, of whom 3.9 per cent. were found susceptible, whereas of 49 Anglo-Americans tested 28.5 per cent. were positive. Fletcher and others have suggested that the microbes causing these diseases are present in the environment, are nonvirulent but antigenic, and evoke early

immunity through wide-spread subclinical infection. While this may well be the explanation, some investigators toy with the yet unestablished hypothesis that antibodies to certain diseases, at least, may be considered as maturing more or less naturally. The finding of diphtheria antitoxin in Polar Eskimos by Heinbecker and Irvine-Jones and by Bay-Schmith in the proven absence of diphtheria bacillus illustrates with anthropological interest the type of reasoning at the basis of this "maturation hypothesis."

Parr at Beirut noted the low puerperal sepsis rate in obstetrical wards of hospitals, despite the very poor risks offered the obstetrician. He suggested that this resistance to puerperal sepsis might be correlated with inborn, or at least existing, resistance to scarlet fever, as measured by the rarity of the disease and the low percentage of positive Dick test reactors. Scarlet fever and most puerperal sepsis are caused by streptococci.

We may now consider some racial features of biological nature which are presumably more inherent in the genetic structure of the individúal than those mentioned. First, we may say that but few diseased conditions are of this category. Not many partake of the singular racial aspect of Buerger's syndrome, thrombo-angiitis-obliterans, which attacks middle-aged male Hebrews from Central Europe almost exclusively.

Atopic manifestations, as illustrated by hay fever, are rare in the Near East, although Americans subject to hay fever at home may suffer from it in Syria. One of them (Kerr) reports that he has never encountered a pure Syrian subject to hay fever.

In his excellent treatise on color vision Sir John Herbert Parsons states the color sense of the Egyptian to be not altogether accurate. One way anthropologists arrive at a knowledge of the color life of a people is from a study of their language. The evolution of the color sense in man has thus been traced. There is some question as to the accuracy of this method. Although the Arabic language has a rich color vocabulary, tests made with colored materials have shown that these terms are applied very loosely, in Egypt brown being more often misnamed than any other color. In discussing the racial aspects of color blindness, Clements states that the percentage of color-blind in Egypt is five, a figure intermediate between the high value of 12.8 per cent. for the Todas and the low values of 0.2 per cent. and 0.8 per cent. for the Malays and Eskimos, respectively. Color blindness is a recessive sex-linked character probably due to multiple factors and is naturally more common in males than in females. There are different kinds of color blindness, and it has been determined in a variety of ways. It is easy therefore to understand that the figures of the past leave much to be desired.

A tabulation is offered showing color blindness in males as revealed by the Ishihara test. These data derive from recent publications by Clements, Kilborn and Beh, and Garth.

	Number tested	Color blind	Per cent.
Europeans and white Americans	4,529	367	8.1
Chinese	2,279	147	6.4
Jew (United States)	200	8	4.0
American Negroes	1,115	40	3.5
Mexicans	1,094	26	2.3
American Indians	1,721	32	1.8

A study on color blindness in Syria by Appelrot is at present in progress. Clements feels color blindness racial differences are significant, whereas Garth expresses a question.

Medical missionaries are quite familiar with the fact that standards of drug dosage for their constituents are different from those they were taught, usually varying in the larger dosages employed. A phenomenon of pharma-

cology with more racial significance than this has been reported by Chen and Poth under the heading, "Racial Differences Illustrated by Mydriatics," in which they review the meager previous work on the subject and add their own findings. They studied the pupil-dilating action in the eyes of 10 Caucasians, 10 Negroes and 10 Chinese of five drugs—cocaine, euphthalmine, l-ephedrine, dl-ephedrine and d-pseudo-ephedrine—and distinctly found that the Caucasians were most and Negroes least susceptible to the mydriatic action of the drugs under investigation, the Chinese being intermediate. It is not a question of differential response to drug action on a physiological basis in the same way that an Egyptian requires more castor oil than a Frenchman, for other parts of the body in these three races do not show such variations.

In 1931, Fox developed a group of thio-carbamides, of which phenyl-thio-carbamide may be taken as a type. This substance tastes bitter to most people but tasteless or even sweet, salt or sour to a certain proportion. Blakeslee and Salmon, and also Snyder, have shown that failure to taste phenyl-thio-carbamide as bitter is inherited as a Mendelian recessive. Taste blindness may thus be applied to racial study. This was first done by Levine and Anderson, who added to existing figures for American whites data on pure and mixed Indians at the Haskell Institute. Parr and coworkers greatly extended this racial survey of taste blindness to include Chinese, Negroes, Egyptians, Aschkenasim, Sephardim, Semenites, Armenians and Arabs. The results obtained when set in order show a decreasing acuity of taste for phenyl-thio-carbamide in this order, Chinese, pure Indians, mixed Indians, Negroes, Egyptians, Sephardim, American whites, Aschkenasim, Armenians, Semenites, Arabs.

Other sensory deficiencies should be sought and, if found, applied to racial study, particularly if they can be shown to have fundamental genetic significance. Thus Blakeslee has indicated a variety of odors, chiefly from flowers toward which different workers react differently, and Parr has collected three cases of persons insensitive to the "peculiar, penetrating, quite characteristic odor, resembling that of peach kernels" of hydrocyanic acid, a poison of considerable medico-legal and industrial significance. Cook has pointed out that a knowledge of these sensory peculiarities makes one more tolerant. Spinach may actually taste as badly to some children as they pretend, and that "finicky" husband who at the table is the despair of his wife may not be merely stubborn after all.

The question of racial odors is one which has as yet received but little scientific attention, although numerous allusions to the subject have existed in general literature for hundreds of years. These allusions are commented upon and the question of the odors exhaled from the skin discussed by Günther. As he makes clear, there are two sorts of odors to be considered. First are those inherent in the race and secondly are odors acquired in a variety of ways, too often dependent upon careless hygiene, squalid conditions of living, articles of diet or even disease. Unfortunately, both sorts have been confused in the past and the odium cast on body odor because of its common association with poor hygiene has so obscured the point that possibly existing true racial odors are overlooked. The point is further complicated by the probability that each race, inured to its own odor and ignorant of it, may apparently be conscious of an odor in other people chiefly because their own odor is absent. However valuable the determination of true racial odor may be, its detection, chiefly subjective, will always be most difficult and because of the odium attached to the matter not an easy study to conduct.

We may lastly consider the applica-

RESULTS OF TASTE BLINDNESS TESTS MADE ON DIFFERENT RACE GROUPS

Group	Worker	Place	Total number tested	Per cent. of bitter tasters
Chinese	Chen Chain	Washington New York	167	94.01
Pure American Indians	Levine and Anderson	Kansas	183	93.9
Mixed American Indians	Levine and Anderson	Kansas	110	87.2
Negroes	Howard Campbell	Alabama Georgia	533	76.5
Egyptians	Hickman and Morcos	Egypt	208	75.9
Sephardim or Southern Jews	Yunovitch	Palestine	175	72.0
American Whites	Snyder	Ohio State U.	3,643	70.2
American Whites	Parr	Washington	439	69.1
Aschkenasim or Northern Jews	Yunovitch	Palestine	245	68.5
Armenians	Berberian	Syria	294	68.02
Semenites	Yunovitch	Palestine	59	67.7
Arabs	Hudson and Peter	Interior Syria	400	63.5

tion of isohemagglutination to racial study. This aspect of immunology deals with blood groups which have been recently discussed in these pages by Lambert and voluminously elsewhere by various writers. The four established groups, O, A, B and AB are becoming increasingly well known because of their determination in selecting donors for blood transfusion and because of their growing use in medico-legal work. The specially demonstrated groups M and N of Landsteiner and Levine, though less well known and much more difficult to demonstrate, have already been found most helpful in expanding the usefulness of the ordinarily determined four types in legal medicine and may well likewise contribute to anthropology. The blood types are fixed biochemical entities not subject to change when once formed in the child. They are formed according to definitely known hereditary laws, and O, A, B and AB may be determined by rather simple technique. Thousands of blood-typing tests have been carried out the world over and, since the pioneer application of blood-type determinations to racial study by L. and H. Hirszfeld in 1918 and in 1919, a great deal of material on serological anthropology has accumulated. Various values are computed from the percentage distribution of the four types in a given folk group from which tables and charts are constructed of value in racial study. Hirszfeld's "biochemical race index" is the ratio of A to B. The values p, q and r express the frequencies A, B and O, as determined from formulae readily available to the student. We shall conclude our discussion with mention of a few

q \ p		I	II	III	IV	V	VI	VII	VIII	IX	X
		0–0.5	0.6–1.0	1.1–1.5	1.6–2.0	2.1–2.5	2.6–3.0	3.1–3.5	3.6–4.0	4.1–4.5	>4.5
A	0–0.5	American Indians	American Indians Polar Eskimos	American Indians	Australians	Belgians Greenlanders Australians	Lapps in Sweden English Maltans		Hawaiians	Lapps in Sweden	American Indians
B	0.6–1.0		Filipinos		Negritos Brazilians Melanesians Icelanders	Samaritans Italians Danish Americans	Christian Arabs French Germans Austrians Bulgars Americans German Jews Serbs Greeks Dutch Swiss	Lapps in Sweden Swedes Norwegians Italians Armenians			
C	1.1–1.5			Igorotes Yorubas Natives of South Africa Moroccans	Madagascans American Negro English Jamaicans	Ashkenazan Jews Aleppo Jews Arabs of North Africa Turks Russians Spanish Jews Americans Slovaks	Moslem Syrian Arabs Armenians Ainus Tcheques Finns Germans Roumanians Korean Japs Polish Jews	Armenians Assyrians Bulgarians	Armenians		
D	1.6–2.0		Bogobos	Sulu Moros Senegalese Sumatrans	Sephardim Jews Samoans Katangans Annanese Javanese Chinese Sumatran Chinese		Druzes Persians Beirut Jews Chinese Japanese Poles Hungarians	Roumanian Jews Japanese Formosans	Japanese		
E	2.1–2.5			Ainus Gypsies	Ainus Koreans	Koreans Chinese	Egyptians Koreans	Egyptians Koreans	Ukrainians		
F	2.6–3.0			Natives of India	Chinese Manchus		Ainus Hungarians Koreans Gilyac				
G	3.1–3.5			Sanal Moros				Ainus			
H	3.6–4.0										

The values for the distribution of the blood typing gene factors O, A and B may be calculated. A two-dimensional chart for any two of these values can be constructed by which different racial groups are arranged together, showing the serological identities. These identities may be coincidental or they may possess definite anthropological values. Such a chart is reproduced above (modified from Parr.) Note the distribution of Ainus in five different squares and the presence of Samaritans with Italians, Danes and Americans,—unusual result due to inbreeding. Note also how new work on American Indians by Matson and Schrader makes necessary a new square, A–X.

only of the many contributions made by blood-typing to anthropology.

Studies on pure American Indians prior to 1933 have indicated that they fall into blood group O. Relatively high concentrations of A exist in northwest Europe and of B in the Hunan areas of eastern Asia. An attractive hypothesis has been that America separated off from Europe and Asia before mutations of A and B occurred. Present-day blood studies on folk groups no longer pure O, A or B should indicate something of the racial relationship and migrations of the past. In 1933, however, Matson and Schrader reported results on heretofore untyped Indian tribes demonstrating a high value for the gene A. Apparently then there was a mutation of A in America as well as in Europe.

Grove's study of the Ainus was a most important contribution, for it put a stop to indiscriminate accumulation of blood-typing racial data. She found that the Ainus, essentially one people, were when tested on their several islands of different blood-typing racial formulae. Parr studied the surviving Samaritans in Nablus, Palestine, with the idea that the inbreeding presumably operative in this small group of people would give them a blood picture entirely unwarranted by their known anthropological features and history. This was found to be the case and justifies the explanation that Grove's anomalous results with the isolated Ainu groups might be explained on a similar basis. It is now believed that given due consideration to technique any blood-typing survey of a considerable number of members of a folk group not unduly interrelated will contribute information of anthropological value.

In 1925 Parr was able to state from blood-typing studies that the Arabic-speaking peoples of old Syria fall into two distinct groups. One of these, the Lebanese, are identified by blood typing as closely related to the Khaldeans and Armenians, and these three groups, according to Kappers, appear from anthropometric studies to be related to the Hittites. The Arab group in Syria, the Adnan Arabs, Parr identified by blood-typing as related to the North African Arabs tested by L. and H. Hirszfeld. Blood-typing tests done by Shousha and by Parr confirm other observations that the Egyptians are dissimilar to the Arabs of North Africa or Western Asia. Parr's results with Persian students at Beirut indicate that they have the same blood picture as the Adnan Arabs. Jews typed the world over present such dissimilar blood pictures we must conclude that although Aschkenasim and Sephardim may once have fairly described two great divisions of this people it is more accurate now to speak of the Jews as a religion than as a race. On the other hand blood-typing tests show that the Gypsy has retained his original racial identity, although he has been centuries separated from his original home.

SOCIAL LIFE OF THE BARAMA RIVER CARIBS OF BRITISH GUIANA

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THE Caribs have lent their name to one of our more picturesque seas, the Caribbean, and, it is said, to the enrichment of our language with the word "cannibal." Accounts of their ruthless methods of warfare and clever navigation of seagoing canoes have on occasion adorned the literature of adventure. But they have long since relinquished their anthropophagous habits and left the scenes of their conquests in the Caribbean, leaving only a handful of half-breeds on a reservation in Dominica, a settlement of so-called Black Caribs in British Honduras, and scattered archeological remains to recall the period of their domination in the islands. At the present time several tribes of Carib stock, speaking their own respective Carib languages, still inhabit the forests and the savannahs of the Guianas, Venezuela and Northern Brazil.

The history of the Caribs is still largely a matter of conjecture. When Columbus appeared on the scene in 1492 a part of the stock had practically completed the subjugation of the West Indies. Carib adventurers had probably reached the east coast of Mexico and Central America in earlier times. And there is evidence of a general slow migration of Carib peoples northward from the Amazon valley into the Guianas and Venezuela. But the clear outlines of these movements are unfortunately lacking.

The Carib Indians now living within the drainage of the Barama River in the Northwest District of British Guiana, who were the objects of the writer's investigation in 1932–33, number between five and six hundred souls, distributed among some thirty-three villages or settlements. The country in which they live is entirely covered with fairly high jungle and is relatively free from penetration by outsiders. The Indians speak a language which in the colony is known as "Pure Carib" to distinguish it from the other Carib languages in British Guiana. The Barama Caribs call themselves *karinye*, meaning "men." They depend upon hunting, fishing and slash-and-burn agriculture for their livelihood. Bows and arrows of several types are their only weapons, and loin cloths are for the most part their only costume. They live in houses thatched with palm leaves but without walls, sleep in hammocks woven of native cotton or tree fiber and, having no domesticated animals, with the exception of dogs and chickens, depend upon canoe travel on the rivers or walking on the trails for transportation.

We are perhaps too often inclined to think of the social life of people whose culture is thus of a "low" sort as perhaps non-existent, or perhaps as approximating that of lower animals. I therefore propose to present here a short and necessarily incomplete picture of the social life of these forest dwellers, in order to show that, while "primitive," it is perhaps not as simple as it may appear at first glance.

It is an axiom of sociology, based upon practically universal experience of investigators, that all societies tend to group the individuals who comprise them more or less roughly according to the individuals' respective social abilities. Nowhere are individuals created

BRITISH GUIANA JUNGLE

THE RIVER AT PLACES IS FULL OF DEAD TREES WHICH MUST BE CHOPPED AWAY IN ORDER TO GET A BOAT THROUGH.

free and equal in the social sense, and because of the circumstances of their physical heredity and social inheritance they vary as to their capabilities for participation in the life of the society of which they are members. Now in Carib society the groups through which individuals play their social rôles have certain resemblances to groups with which we are familiar, but on the whole the principles of grouping are somewhat foreign to our way of thinking.

The following types of grouping characterize the society of these people at the present time: (1) the family or household; (2) the kin; (3) the extended family; (4) the friendship group; (5) the settlement; (6) the kanaima cult. Sex and age also play a part, in that, outside of the immediate family, the members of the same sex and generation tend to be closer to each other than other individuals in the same group.

It need hardly be mentioned that the groups in Carib society are few in number and relatively indistinct in outline, as compared with those found in many more "advanced" cultures, and for this reason they have rarely been recognized by outside observers.

The family or household group is composed of a man and his one or more wives and their unmarried children. Each family has its own house and it practically never occurs that adult individuals other than the spouses and their children are included in the household group. Other relatives or friends who wish to be near the family have their own houses in the vicinity. There are no individuals above the age of about twenty who are not married or who do not have definite plans to be married, and we may therefore say that every individual in the community belongs to a family. However, it is obvious that in every society an individual may belong

to one or both of two kinds of family, namely, a family of orientation and a family of procreation. Now in Carib society, as among ourselves, it is practically the universal rule that one joins his family of orientation by being born into it. But the formation of a family of procreation, which involves marriage, follows a somewhat different pattern than among ourselves. For a young Carib of either sex, puberty is the introduction to several years of sexual experimentation, during which the young man visits and sleeps with as many marriageable girls as his fancy and strength will permit. Pregnancies rarely result from these affairs, perhaps because of the use of several native contraceptive and abortive methods. Eventually the young man chooses a girl with whom he desires to "settle down" and asks her father for her. The old man requires the suitor to clear and plant a field and to build a house in the settlement of the future father-in-law. These are feats which require several months, during which period the suitor occupies the house of his fiancée's father and enjoys the favors of the girl while contributing his hunting spoils to the family larder. In this manner not only is the constancy of the young man tested, but his ability as a provider is proved to the satisfaction of the girl's family. When these tests have been passed, the young couple move into their new home and take up the course of married life. No religious ceremony solemnizes the marriage. Thus is a family of procreation established. The young married couple live in the settlement of the girl's family until the birth of the first child, after which they may establish their residence elsewhere. Subsequent wives acquired during or after the lifetime of the first wife are taken with the permission of

CARIB INDIAN HOME AND CLEARING
IT IS WASH-DAY IN THIS SETTLEMENT.

CARIB INDIAN HOME

BUILT IN CLEARED SPACE IN JUNGLE. FIREWOOD AND TEXTILES PROVIDED BY OWNER.

their fathers, but without the house and field building tests which are required for a first marriage.

Within the household there exists no formal distinction between the children of polygynous and subsequent marriages, and a child's position in the family depends largely upon its personality and age. The same is true of wives in polygynous families.

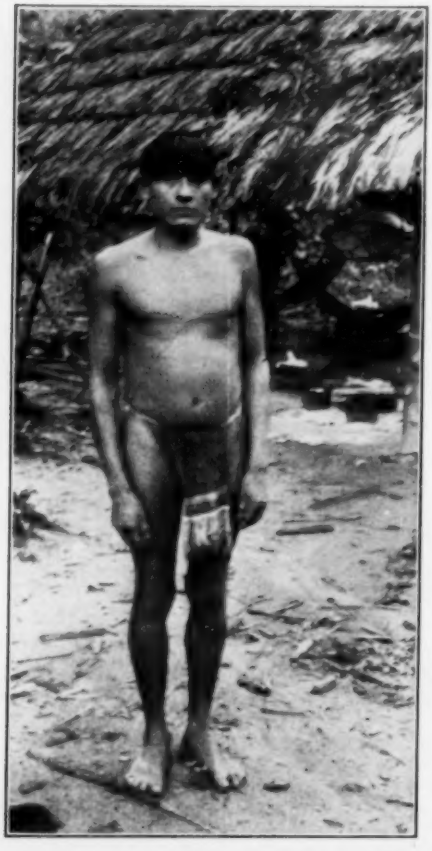
The position one occupies in the household group or family depends upon whether the group represents one's family of orientation or one's family of procreation. If one is a child he is subordinate to both of his parents. If one is a married woman she is subordinate to her husband. If one is a married man he is superior to all in the household.

The household group is the primary educational institution of Carib life; boys are trained in the duties of men by their fathers and girls are trained in the duties of women by their mothers. In the absence of club houses or other extra-curricular educational institutions the home is the agency for the dissemination and formation of the socially accepted attitudes. The home is also the primary economic unit of the community, and in economic activities there is a fairly rigid division of labor. Men do the hunting, fishing, house-building, making of basketry, field-cutting, weapon-making and some of the planting. Women do the housework, field work, care for the small children, and make the pottery, raiment and hammocks. All economic goods which have been modified by human hands have an individual owner who can alienate them on contract. Every article about the house belongs to some one in particular. No religious or political functions are performed by the household group.

Outside the more intimate relations of the household group lies the larger group of the kin, only the general outlines of which can be sketched here. In the broad sense the kin may be said to include all those individuals to whom the individual in question can trace a relationship which is designated in the terminology. This includes five generations only. The general group of relatives thus defined is regrouped according to certain principles of the classificatory relationship terminology in use. The general characteristic of a classificatory relationship terminology rests in the fact that any given relationship term may apply to a whole class of individual relatives, whereas a strictly descriptive type of terminology uses a single term for each individual relative. Thus mother, in our system, can in the sense of relationship be applied to only one individual among the speaker's relatives, whereas a Carib in speaking of his female parent uses a term which also means "mother's sister," "mother's mother's sister's daughter," and, in fact, all the female relatives of his mother's generation who are related to him through the female side of his mother's family. In speaking of his father he uses a term which means not only "father," but also father's brother and all male relatives of his father's generation through the male side of his father's family. Now these relatives who are related to him through the female side of his mother's family or through the male side of his father's family comprise a group which is known to anthropologists as the "parallel relatives"; the members of his own generation who are thus related to him he calls "brothers and sisters," although the individuals thus addressed outside of the immediate family we would call cousins. This group of parallel relatives forms a group into which one may not marry. Although a Carib is perfectly aware of the members of his own immediate family as such, in the kinship terminology he makes no distinction between these and the parallel relatives whom he considers to be brothers and sisters, fathers and mothers and children, according to the generation in which they stand in relation to himself. However, there still remain a large number of relatives who do not come into this category, for instance, mother's brother and father's sister. Thus all the relatives which are related to him through the male side of his mother's family and those related to him through the female side of his father's family, a Carib calls by a different set of terms, distinguishing them from the parallel relatives. This group we may call the "cross relatives," referring not to their disposition, but to their status in the relationship system. A Carib can always tell you which individuals are actually related to him, but for practical purposes, the terms which are used for the members of the cross relative group are also usually applied to all strangers who are not known to be members of the parallel group. This usage is primarily connected with the belief that the use of the personal name endangers the owner of the name through its possible magical misuse.

It is therefore clear that a Carib is brought up to consider one portion of his kin, namely, the parallel relatives, as closer to him than the other portion, the cross relatives who are terminologically undistinguished from other persons. It is interesting to note in passing that this division of the kin is not connected with an organization. No institution of this kind exists among the Caribs at the present time, nor is there historical evidence pointing to its former existence. The Barama Carib type of kinship organization is quite typical of that found among all the other Carib tribes concerning which we have information. The actual kinship usages among the Caribs support the view that, in the

absence of sib organization, the terminology is closely connected with the customs of the levirate and the sororate which are actively functioning at the present time and seem to have been from time immemorial. Polygamous marriages are frequently with the sister of the first wife. Likewise a widow always marries the brother of her deceased husband. The distinction between parallel and cross cousins becomes clearer when seen in the light of these customs. In many cases marriage with the child of father's brother or mother's sister in such society would mean marriage with an actual half-sister or half-brother.



A YOUNG MAN IN NATIVE DRESS
THE LOIN CLOTH IS WOVEN FROM NATIVE COTTON AND COLORED WITH NATIVE DYES.

THE PROFILE OF A YOUNG CARIB INDIAN WOMAN
THE DRESS IS SUSTAINED ALWAYS BY ONE SHOULDER STRAP.

Such incestuous marriages, with very few exceptions, are prohibited in all human societies.

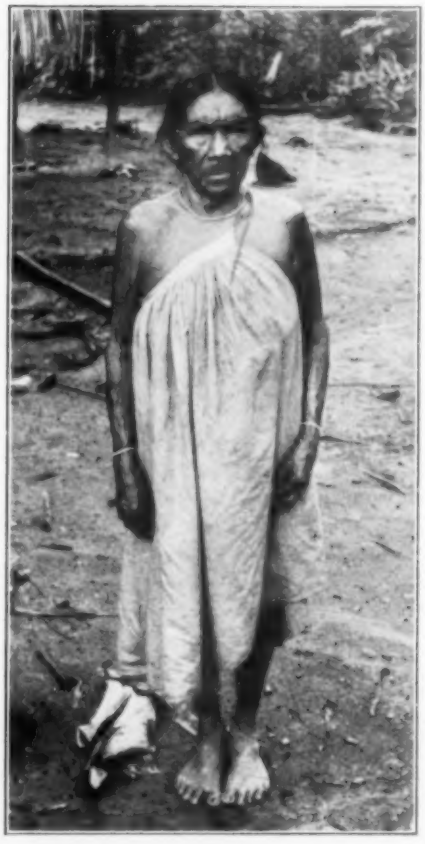
The persons a man includes among his parallel relatives remain in a special relationship to him throughout his life. "Brothers" tend to group together to form a settlement and assist one another in the social and economic affairs of the settlement. They support one another in feuds and retaliations. In all activities the members of the group of parallel relatives cooperate more closely than do other relatives. Membership in the group begins at birth and continues for life. Due to the customs regulating residence after marriage there is, however, no necesssary connection between locality and the kin.

A third type of grouping is the extended family, the immediate family which is, in other words, extended by the marriage of its members. When a

A YOUNG CARIB INDIAN WOMAN
DRESSES ARE WORN ONLY WHEN STRANGERS ARE ABOUT OR ON GALA OCCASIONS.

girl marries, her husband becomes for a time at least intimately associated with her family, because of the custom requiring the husband to perform services before marriage under the eye of his future father-in-law and after marriage to live in the father-in-law's settlement at least until the birth of the first child. Thus a family upon the marriage of its daughters from one point of view undergoes a special transformation consequent upon the addition of strangers in the persons of sons-in-law. The latter, however, do not take the place of the sons who through marriage have joined other extended families. The husbands of the daughters are not taken into the family, which still maintains its biological limits and individuality, as shown by the fact that a special relationship of deference, not formalized into a strict "parent-in-law tabu," but resembling it, exists between the young men and their wives' parents. During the period that marriage remains matrilocal the sons-in-law cooperate actively with the fathers-in-law and with other members of the latter's family who still remain at home. Later opportunity or preference usually impels the young couple to move elsewhere, but a bond still remains between the husband and his wife's kindred which is reflected in mutual cooperation. This bond is, however, slighter than that uniting a man and his parallel kin. With the death of the wife or of the father-in-law mutual obligations are considered ended.

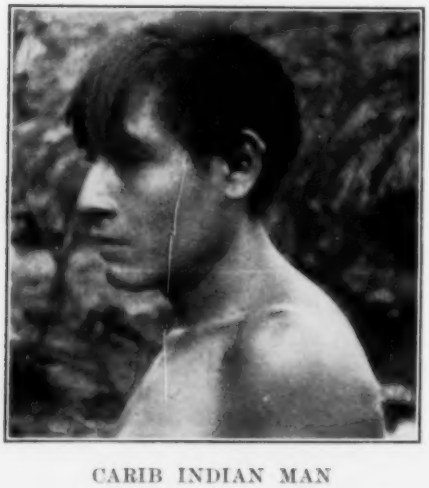
The political unit of Carib society is the settlement, and its basic principle is the common locality of its members. Settlements vary among themselves in



CARIB INDIAN WOMAN
SHOWING USUAL SHAPE OF DRESS MADE FROM TRADER CLOTH.

MOTHER AND CHILD
NOTICE METHOD OF DRESSING THE HAIR.

size from 15 to 70 individuals. Factors which determine membership in this group are kinship, friendship, marriage and accident of birth. Termination of membership is by individual choice, sentiment of the community antagonistic to the individual in question, death and economic factors, such as the exhaustion of the soil and of the hunting grounds. Each settlement is presided over by a headman whose authority is decidedly limited and dependent upon his personality or physical strength. He is usually chosen by acclaim for life or for the existence of the settlement by the adult men of the group. Community affairs are decided informally in conversation among the adult men when they are together during drinking sprees.



CARIB INDIAN MAN
PROFILE OF PHYSICAL TYPE.

Friendship is a strong factor in the social life of both men and women. Regardless of home, kinship or settlement individuals are often especially intimate with other individuals for no other reason than personal congeniality. For practical purposes this form of grouping often lies within the settlement, although I know of cases of men making rather extended tours to visit distant friends. There are always groups of men friends who go hunting together, who build canoes together, tell jokes together, and so on. The same sort of thing is true among women, who, however, due to modified matrilocal marriage, tend to choose their friends among their relatives to a greater extent than do men. In the matter of lending, assistance in work and sociability, friendship plays at least as large a functional part as does mere kinship, which, when it stands alone, implies for the most part, as among ourselves, rights and duties frequently less vital than those of friendship. The difference, of course, lies in the fact that friendships may be terminated when for any cause the congeniality essential to them disappears, whereas kinship ties exist in a stronger or weaker condition for life.

The last type of grouping in Carib society to be considered here is the secret kanaima cult, membership in which is confined to men. Kanaimas are hated outcasts who have voluntarily deserted respectable society to roam about the deep jungle perpetrating outrages on individuals unfortunate enough to come in contact with them. It is difficult to obtain precise information concerning

them, because no native will admit having been a member of the cult. But the evidence seems to show that such an organization actually exists, although many of the activities attributed to it are doubtless the products of terrified imaginations. Men who have misogynistic temperaments as well as those who have been unable to obtain redress for an offense against themselves in any other way are said to compose the recruits. Once they have taken up the life of the kanaima, they must leave family, kin and friends, and forsake all the advantages of the native culture. They are taught to live a life of extreme hardship without shelter or the ordinary foods and, in the process of training, are said to learn the magical procedures whereby they can overtake an unsuspecting individual in the bush, anesthetize him, twist his joints while he is unconscious, and send him home with fever, where he dies within a short time. It is believed that kanaimas pierce the tongues of their victims so that the latter are unable to give information concerning what has befallen them, and after the victim has been buried the kanaimas, to complete their task, must reach the corpse and drink the liquids of decay from it. From the social point of view the membership of the cult, if such actually exists, represents an important, though perhaps temporary, division of the population, a group which is, however, outside the limits of normal society.

CARIB INDIAN WOMAN

THE HAIR IS OFTEN BRAIDED AND SOMETIMES COILED ON THE BACK OF THE HEAD.

Six types of grouping have been described, the entire range of social groups in Barama society at the present time. The first five types, immediate family or household, kin, extended family, friendship group and settlement, may be considered basic features of the social structure. The kanaima cult is a specialized grouping not directly connected with the social organization of the community as a whole.

Sex and age, factors which are pres-

ent in all societies, further affect the social life of the Carib community. Here, as elsewhere among human societies, are infants, adolescents, middle-aged adults and old people. Here also are males and females. However, no groupings in Carib life depend primarily upon either of these factors.

The only specialists in Carib society are headmen, priests and sorcerers, and it may be asked why these are not assigned to special groups. Although each of these officials is distinguished from the commonalty on account of his position, each is a lone wolf in his official capacity, requiring in his official functions the assistance of no organized group of colleagues. Furthermore, each settlement has only one headman and usually only one priest and one sorcerer, never more than three, so that a local basis for grouping is absent. In the frame of Carib society as a whole these three officials may be said to belong respectively to three professional classes, but these classes are not in any sense functioning groups because the members, although fulfilling similar individual functions, do not cooperate in these functions.

The Carib cultural adaptation to the jungle environment, depending upon a wide hunting territory and small fields which must be frequently abandoned for lack of fertilization, necessitates small and isolated communities and promotes individualism in economic activities, tendencies which are not conducive to highly organized social life.

Enough has perhaps been said here to indicate the simplicity and lack of formalism of the Carib social structure. The Carib society is essentially a collection of small hordes, organized into four or five other types of groups, but without formal stratification, depending upon age, wealth, social position or any other factor. Those familiar with Australia will at once recognize the contrast between this sibless society and the elaborate clans, totems groups, marriage classes, sections, sub-sections, cycles, pairs and other subdivisions of the central and some of the northern tribes of the continent. The Carib is not obsessed with kinship terminology, as many of the Australians seem to be. Here we find none of the elaborate social stratification of, for instance, the American Northwest Coast or of Polynesia. Here also is nothing of the centralized governmental control inherent in the social system of the Incas or of the West African kingdoms. Nor does the kinship group of the Caribs possess either the economic functions that it does, for instance, among the Ifugao of Luzon or the Kazaks of Central Asia or the political functions of the Iroquois clan. It seems to be one of the simplest social systems of which we know in the jungle portion of South America, for the Arawaks are known to have matrilineal localized clans, the Witoto and Boro have patrilineal gentes, etc. Much remains to be learned concerning the social life of the forest tribes of South America, and when this information is available the place of the Caribs on the scale of complexity will be better known. But with all its simplicity, as we have seen, Carib society organizes its members into groups, as do all societies, for greater efficiency, and the individual's social life is far removed from that of the lower animals.

HOUSE AND VILLAGE TYPES OF THE SOUTHWEST AS CONDITIONED BY ARIDITY

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THE sub-tropical hot desert type of climate of the lower Colorado River drainage basin and the upper valley of the Rio Grande with their bordering steppes constitute a region of distinct character as contrasted with other parts of the United States. Here, then, we may look for distinctive human adjustments to climatic conditions resulting in peculiar or indigenous forms. Most universal and conspicuous of cultural forms are house and village or community building types. Yet often in the more highly developed districts of the arid Southwest one fails to be impressed with anything distinctive architecturally except a few scattered old houses or neglected old buildings in less frequented locals which have failed to share in the general quickening prior to 1930. Outside of New Mexico, where a conservative Spanish-speaking population of low living standards is considerably in the majority, there has been considerable leveling of structural types due to mobility of population and fluidity of ideas shared with other parts of the country. So local indigenous forms have often been submerged among the exotic styles introduced through a rapid influx of population steeped in the culture of a different clime and uninured to the modes of the desert. Will the desert eventually impress its stamp upon this heterogeneity to produce a fusion in harmonious adjustment?

For that which is more typically desertic, we may look to the simpler indigenous cultures and even to the adjustments of the American pioneer settlers. Indian cultures were supplemented by Spanish or Mexican culture and house types. The first American settlers, isolated from their kind, adopted the forms of those who had preceded them in the land. Later settlers, coming in larger numbers and less completely cut off from old cultural ties, employed their accustomed building methods and materials, but modified their style of building to suit the climate.

CONDITIONING FACTORS

The character of the desert house is determined largely by two sets of natural facts: (1) Conditions imposed by climate; (2) materials available for construction.

The climatic factors which taken together set apart the areas designated as a climatic province in the United States are the same as characterize all the arid regions of the world bordering on the Tropics. They are: (1) *Low rainfall*, generally less than 10 inches, although the limit will vary with temperature and other conditions; as affecting cultural forms, no definite limit can be set. (2) With low rainfall invariably goes *low atmospheric humidity*, which more directly affects human comfort. (3) Also continuous sunshine. (4) Very high summer temperatures. (5) Mild winters with little freezing weather. (6) High diurnal range, commonly over 25 degrees.

The matter of building materials is of paramount importance where the desert community is isolated or the standard of living is low, and diminishes in importance with ease of communication and

greater wealth. The materials of the desert are earth (adobe) or stone, with perhaps sufficient woody growth to supply beams or even upright supports.

Clayey soil makes up for the scarcity of wood in the arid zone. It can be easily molded and will absorb substances which solidify and harden it when dried in the sun or baked in the fire. The clay is also used for cooking utensils and for vessels to contain and to cool liquids, as the well-known *olla* of the Southwest. In Northern Africa and Southwest Asia even clay furniture and earthenware chests are used. If one is looking for beginnings, he will learn that architecture using bricks did not originate in the places where it is developed farthest to-day, but in the arid regions of the world. In districts arid enough for the use of sun-dried brick, clay has always maintained its supremacy. The great Chaldean and Assyrian palaces, even those which succeeded them in western Asia up to the time of Alexander, were built almost exclusively of clay.[1] "The native of such regions is earthy in the most literal sense of the word;—earth in his domicile, whether he builds upon the ground or conceals himself within."

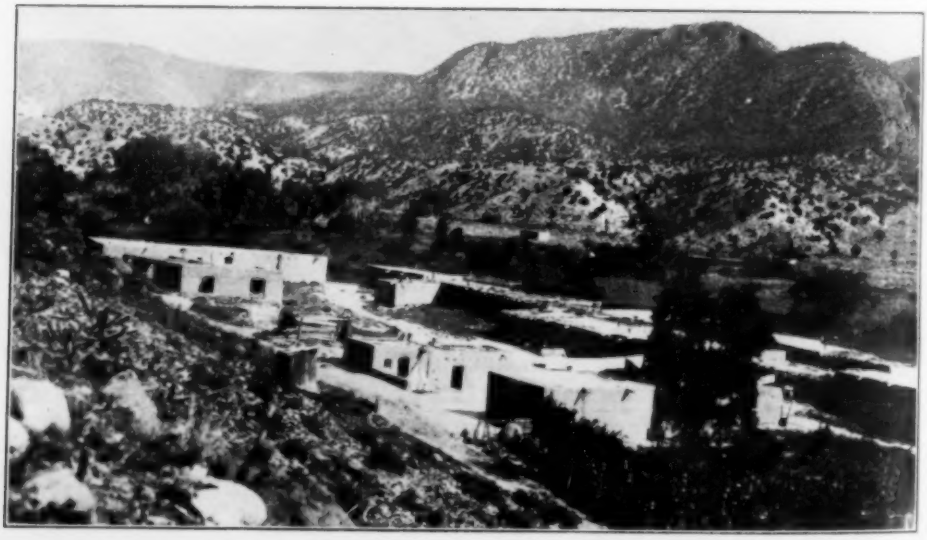
The need of protection from nomadic tribes is a social factor which often has played a large part in structural arrangements.

The Typical Desert House Type

In its simple form the mud or adobe block house, characteristic of the Mexican villages, may be taken as the general and well-nigh universal type of arid and semi-arid fixed habitations. Toward it the more primitive house types tend in their evolution. From it as the basic form emerge more elaborate forms of more highly bred cultures of the dry regions.

The adobe house is usually simply rectangular in form, flat-walled and flat-roofed, with little window space. If larger it takes the form of an L, T or U, or it may enclose a court. A space partly enclosed by the house may be completely enclosed by an added adobe wall forming a "patio." Built of the earth on which it stands, the drab buff of walls and roof blend with the same color of the soil. The universality of

[1] Vidal de la Blache, "Principles of Human Geography." Translated from the French by M. T. Bingham, pp. 240–241. New York, 1926.



TYPICAL MEXICAN OR SPANISH VILLAGE ON UPPER RIO GRANDE, N. M.

STREET IN ALCALDE, N. M.

this as a desert form is evidence of fitness to the environment. The thick adobe walls, roof and floor are effective insolation from the glaring heat of the desert. Deep-set windows in thick walls emit little or no direct sunlight, and from the heat of the desert the cool dim light is inviting. During the heated part of the day doors and windows are closed and the house remains very comfortably cool until lengthening shadows break the glare of the sun and the heat begins to moderate. During the night the temperatures drop from 25 to 35 degrees or even more, and the house is again effectively cooled for the coming day.

It seldom rains; so the pitched roof of rainy or snowy climes is not needed. The roof is commonly built by laying beams or rafters on top of the walls. Across these, poles are laid close together. These, covered with grass or weeds, support in turn a few inches thickness of earth. Such a roof may suffer severe erosion during occasional sporadic downpours characteristic of the desert. Or if there is an unusual rainy period, the roof and even the walls may become soaked, and the house with contents seriously damaged.

In parts of the world where the supply of wood for beams is scant or has been depleted, an inverted basin-like dome or cupola must be resorted to to cover the space between walls. With the disappearance of the supporting wooden framework for the roof goes also that of the runway for dripping rain. Cupola construction, mothered by necessity, is also widely distributed, and represents the highest structural achievement of some groups. It is an especially common form through southwestern Asia and may be witnessed even in the Sahara. In Kurd villages of Turkestan and the villages of the Alepp Plain of Syria, the earthen or brick dome becomes the entire house, a beehive form with the flat walls eliminated.[2]

Instead of being domed, the rectangular rooms are sometimes barrel-vaulted, a form especially common in Egyptian villages and in Mesopotamia. Neither the barrel-vault nor the cupola have entered into the primitive house construction of the Southwest, most likely because of the availability of material for beams large enough for the roofing of small structures. However, the rudiments of such construction are found in

[2] Illustrations, *Nat. Geog. Mag.*, Vol. 54, October, 1928, p. 502, and October, 1930, p. 494.

the sizable ovens of the Papago Indians, the Hopis and the Rio Grande pueblos.

The simplicity of the adobe house is also due in large part to the fact that the climate makes so few demands upon shelter. Most of the life is out of doors. Even the outdoor patio and the roof of the house become important outdoor adjuncts of the house and accommodate a large share of the household activities and diversions. In this respect the native of the Southwest is somewhat like the Egyptian, who does not build for his own use and comfort, but who lives out of doors in the open sunlight the year around, using his house only as a shelter for the night. Nor does he need shelter like the peasant of northern countries for the long gloomy evenings of the winter.[3]

The clay of the desert is rich calcareous material which in nature forms calcareous concretions or the hard stratum of "caliche" beneath the surface. This, dried in the adobe blocks, hardens and binds them. Its natural consistency is reinforced with weeds or stubble mixed with the mud, and it is then put into molds and allowed to harden into blocks of varying sizes; but blocks about 14 inches by 12 inches by 4 inches are the most conveniently handled. In ancient Egypt, when stubble or "straw" became scarce, the enslaved Israelites, with the other brick-makers, had to forage for their own straw, and finally had to make a poor quality of brick without straw.[4]

The adobe itself may be scarce or difficult to obtain, in which case stone-wall construction takes the place of the earthen walls. Where both are available, stone and adobe walls will each be employed, or the same wall will contain large proportions of both materials. In lower Egypt no stone and very little wood is used, hence the mud house; but in upper Egypt, where there is plenty of stone, the houses, though similar in form, are of stone construction.[5]

Primitive inhabitants of the desert, other than oases dwellers, are necessarily nomadic. Their house forms, if such they may be called, seldom go beyond the most primitive forms, as tents or lean-tos, usually covered with the skins of the animals incident to the nomad's pastoral existence. Felt made from hair or wool may also be used, and with commercial contacts, the hides or felt may give way to canvas. In restricted areas in the southwestern states, the small tepee tent of the sheep-herder is the only human shelter to be found even to-day.

Until recently primitive village dwellers of the Southwest were subject to raids from the nomadic Apache Indians, who took refuge in the mountain fastnesses bordering the arid basins. To the

[3] Jean Brunhes, "Human Geography." Translation by I. C. Le Compte, pp. 102–104. New York, 1920.

[4] Genesis, v: 6–19.

[5] Brunhes, *op. cit.*, p. 107.

INDIAN PUEBLO, ISLETTA, N. M.

east were also the Comanches, who followed the wild herds of buffalo which supplied them with the necessities of life. The shelters of these tribes were necessarily of the simplest construction. With the depletion of the buffalo herds the Comanches too became raiders. The Navajos of northern Arizona and New Mexico, at first primitive hunting nomads and later pastoral nomads, similarly harassed the peaceful pueblos on the Rio Grande and those of the Arizona Hopis. In their houses or hogans they have since failed to keep up with their general progress.

"Like house, like village." In Arizona the Mexican villages are seldom more than adjuncts of the American towns; but in New Mexico, they are as distinctively Mexican and as frequent as south of the International Boundary. Low and dull-colored, they squat upon the land, blending with the color of the dry earth, or massed on slight eminences they appear as flat prominences. Except for the arrangement of houses in rows or around courts, they have little plan. Seldom is a house more than one story high. Rising above the general flatness of the village is one conspicuous structure, the church, surmounted by a wooden cross. Yet how common is the type with a few variations in many parts of the world.[6]

[6] Compare description of Egyptian Village—Brunhes, *op. cit.*, p. 122.

Ancient or Prehistoric Construction and Primitive Elements

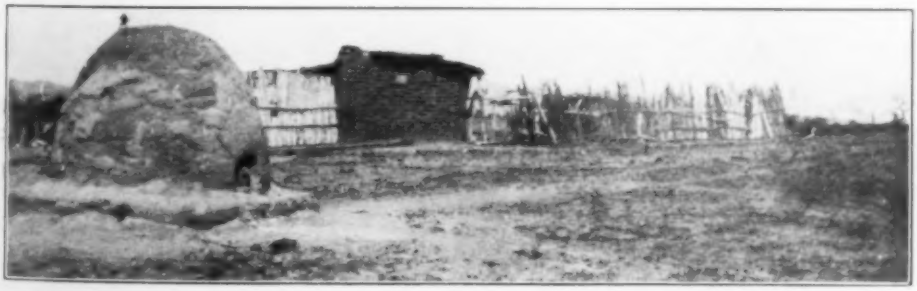
Through central and southwestern Asia and through Egypt, ruins lie upon ruins. For, "if the house is fragile, the village is also ephemeral."[7] Contrasting the durability of earth and stone, "Thucydides, in an oft-quoted passage remarks that if Athens and Sparta were to fall in ruins anyone unfamiliar with their history would be tempted, after a glance at their monuments, to exaggerate the importance of the one and underrate the importance of the other."[8] In the Southwest, too, hundreds of ruins, mostly reduced to mounds, are widely scattered. The more advanced of these prehistoric cultures do not date so far back in Asia and Egypt, but even here the ruins of an older village are often found under those of a later one.[9]

The rectangular forms in house construction have in most cases been preceded by round forms. Earliest types of shelter found in the Southwest, excepting the cavate dwellings, were the pit houses, excavated in flat surfaces and having a superstructure. As the latter developed, the dwelling emerged from the ground and evolved into the earthen-walled house. The culminating prehistoric structures, as seen in the

[7] Brunhes, *op. cit.*, p. 122.

[8] Vidal de la Blache, *op. cit.*, p. 255.

[9] Compare Vidal de la Blache, *op. cit.*, pp. 243–247.



PAPAGO INDIAN BAKE OVEN AND HOUSE BUILT OF ADOBE BLOCKS, VILLAGE OF COBABI, SOUTHERN ARIZONA

"Big House" at Casa Grande Ruin on the Gila River and the splendid masonry compounds of compacted terraced houses, often built in recesses of the cliffs in the Plateau Country, are the climatic expression of the need for protection in a period of beginning decline. The four-story "Big House" at the Casa Grande Ruin is believed to have been a watch tower. Such structures were quantitatively hardly more important in their day than were the masonry temples of ancient Egypt, which then as to-day shadowed the mud hovels of the populace. The one-story house was the rule.[10]

ment were successfully tried.[11] Very likely the walls reinforced by juniper rods were in turn preceded by houses with thinner mud-plastered wattle walls such as those of the Pima and Papago Indians of to-day or were contemporaneous with them. Before leveled for modern irrigation, both the Salt and Gila River plains had a considerable number of mounds, indicating the support of a large population. A few of the larger still remain. In the Salt River alone there were 240 miles of acequias, which may have watered over one hundred thousand acres of land, though not likely all at the same time.[12]

KUKOMALIK, PAPAGO INDIAN VILLAGE OF SOUTHERN ARIZONA

The builders of Casa Grande had not learned to make adobe blocks. The walls were piled up without the use of forms. Caliche was puddled with water to make a stiff mud, carried in baskets and piled along in courses and patted into shape. When dry it was ready for the next course. In a preceding stage, as found in one of the oldest compounds, the walls were reinforced with rods of juniper which must have been floated down the Gila or carried many miles from the mountains to the east. These core rods were bound together with arrow-weed switched and plastered with about four inches of caliche mud on either side. No doubt, as the juniper became more scarce or more distant, walls without reinforce-

[10] H. R. Patrick, "The Ancient Canal Systems and Pueblos of the Salt River Valley, Arizona," Phoenix, 1903; O. A. Turney, *Arizona Historical Review*, Vol. 2: 45–46, April, 1929.

Primitive Antecedents Illustrated in the Construction of Southwestern Indians

The houses of the present-day Indians of the lower Colorado Basin are further suggestive of the primitive types which antecede the typical adobe house. These forms and the changes are common to all the southwestern tribes, *viz.*, the Pimas and the Maricopas on the Gila and Salt Rivers, the Papagos in the desert south and the Mojaves and Yumas on the Colorado River.

The most common modern Papago or Pima house is a one- or two-roomed flat

[11] Edna Townsley Pinkley, "Casa Grande, the Greatest Valley Pueblo of Arizona," pp. 9–13, Arizona Archaeological Historical Society, 1926. See also J. W. Fewkes, "Casa Grande, Arizona," 28th Annual Report of the Bureau of Ethnology, 1906–07, pp. 33–179.

[12] O. A. Turney, "The Land of the Stone Hoe," p. 5, Phoenix, 1924.

ONE OF THE TWO GREAT HOUSES AT TAOS INDIAN PUEBLO, N. M.

earth-roofed hut built of adobe blocks. It differs from the common Mexican type of adobe house in that the roof extends over the walls instead of the walls extending above the roof. The walls, built wider at the top, curve outward, so that the rain-water will drip off instead of following the wall, and the house may appear as if its walls are falling out. Most Pima houses have stoves, but most Papago houses depend upon a fireplace and chimney built on to the house. Side by side with this type of house is the old and more primitive wattle or mud-and-stick house. Strangely, the Pimas, who have the more fertile well-watered lands and are in more immediate contact with the white civilization, adhere in larger proportions to the more primitive type of dwelling than the Papagos.

Just across the Mexican boundary, on the southern fringe of the Papaguerio, the Indians are isolated, poor and backward. Here the wattle house is the rule, but no poorer than those of their Mexican neighbors, whose homes are identical in construction.

The wattle house is supported by four or more crotched cottonwood posts over which are laid cottonwood or mesquite beams. For the side walls, poles are fastened to the supports, inside and out about two feet apart. To these horizontal ribs are then fastened vertically a wall of arrow-weeds, or ribs of the sahuaro, or giant cactus (*Carnegiea gigantea*).

STREET IN JEMEZ INDIAN PUEBLO, N. M.

and the whole is plastered with adobe on both sides. A number of cottonwood beams laid over the top support the roof. Poles are laid across these at right angles, and over the poles a covering of arrow-weed. A covering of about a foot of mud finishes the roof. Arrow-weed and cottonwood grow only on the river flats, so the Papagos of the desert use ocatilla stems or sahuaro ribs in place of arrow-weed stems, and mesquite, paloverde or ironwood instead of cottonwood. When new, the wattle house presents a fairly finished appearance, but the outer adobe soon crumbles off if not renewed.

Originally the Pima homestead consisted of a primitive hut resembling an overturned wash basin, together with an outdoor kitchen and ramada for shade. The round hut or "kih" have only recently been entirely abandoned, except for several in Papago villages, where they are now used for storage. The roof of the kih was supported by a framework like that of the present wattle house. Around this a circle of light willow poles was set in the ground and bent over on the support with their tops bound together and the whole covered with the earth. The kih was from ten to

DETAILS OF PUEBLO ARCHITECTURE, JEMEZ, N. M.

Some of the wealthiest Indians on the Pima Reservation continue to live in such houses, so adherence to them can not be laid entirely to poverty.

Near the house there is often a storehouse for grain, perhaps without the mud plastering, and an arbor or ramada, with the roof like that of the house supported on crotched posts. Near about the Pima house or cluster of houses is a well with a pail on a rope over a pulley, as along the Gila or Salt River the water table is near the surface. The Papago village is fortunate if it has one dependable well or spring. Near the village is the ubiquitous corral, constructed of brush or staked poles.

twenty-five feet in diameter and only about five feet high inside. Erect posture was not possible, and the doors were so small that they had to be entered on hands and knees. There was no smoke hole, so the room was grimy and smoky.[13] While bearing no resemblance to the wattle house, their construction had so much in common to it that the step from one to the other was very easily made. The new type was suggested under Spanish or Mexican influence. The outdoor kitchen persisted until chimneys or stoves were introduced and is still employed in isolated

[13] Farish quotes James E. Rusling, Vol. 6, pp. 9–11.

REMAINS OF CAVATE DWELLINGS IN VOLCANIC TUFF CLIFF, PUYÉ, N. M.

villages. The ramada persists and is often an adjunct to the hut.

Protective Adaptations

During the period of most extensive Apache vandalism, prior to 1878, Pima and Apache villages became more concentrated; with greater security the larger villages tended to break up. The Papagos fortified several suitably situated elevations, but never was their manner of building directed to this end, as was that of the builders of the terraced piles of prehistoric and modern pueblo of the Southwest.

On the southern margin of the Papago Country in northern Sonora may be seen numerous short rock-walled platforms or trencherias located on detached hills or mounds suitable for defense or lookouts. At a distance these terraced rows of houses must have

THE CLIFF PALACE RUIN, MESA VERDE NATIONAL PARK

ADAPTATION OF PUEBLO ARCHITECTURE IN MODERN BUILDINGS, SANTA FE

crudely resembled some present-day Saharan villages. Sauer believes them to have been places of residence for agricultural communities situated and built with a view to greater security.[14] Like their probable contemporaries in Arizona these people also reared fortified compounds in the lowlands and surrounded them with walls,[15] but only in their later history as they came under the threat of nomadic raiders.

In the highlands to the north, the village became a single unit, culminating in the terraced pueblo, which in the times of greatest danger was built on mesa summits or in an inaccessible recess in the cliffs. The terraced pueblo is at its best to-day in Taos, New Mexico, with its two great four- or five-story houses. It is still characteristic of the

[14] Carl Sauer and Donald Brand, Univ. of Colorado Publications in Geography, Vol. 5, No. 3, pp. 67–148. Ref. pp. 67–79 and 114.

[15] Sauer and Brand, *op. cit.*, p. 74.

THE MAIN STREET OF YUMA, ARIZONA, SHOWING SIDEWALKS PROTECTED FROM DIRECT SUNLIGHT

Acoma Pueblo, New Mexico, and the Hopi pueblos of Arizona. But most of the Indian pueblos have flattened out with the advent of peaceful security.

The prehistoric cliff dwellers in the Southwest, as in other parts of the world, were often partly cavate dwellers, some walling up caves and others hewing rooms out of the rock in the rear of the built structures. Of such kind were Puyé and the noted Frijoles Canyon, New Mexico. Similar rooms were crudely carved in the soft Tertiary limestone of the Upper Verde Valley in Arizona.[16] These, as cliff dwellings elsewhere, were supplementary to important sites above the cliffs, as at Puyé or on the valley floor below, as in Frijoles Canyon.

In Cappadocia, near the dry heart of Asia Minor, the troglodyte villages, such as Udj Assaru, Martchan and Urgub, have the same peculiar combination of semi-cavate, semi-cliff terraced and open villages as those of Puyé and Frijoles Canyon. In both cases the cliffs are easily carved volcanic tuff and the natural erosion forms are more accurately duplicated than even the dwellings.

Terraced villages built over summits or on slopes are common protective devices of the arid regions of the world. Striking examples are the Saharan Villages of Siwa and Ghardia and many Tibetan villages.[17] The Hopi villages, especially Walpi and the New Mexico pueblo of Acoma, piled up on the small rocky summit areas of cliff-bound mesas in Northern Arizona, have their peer in Yezdihast, Persia.

Cultural Modifications of Desertic Architecture

Practical considerations or purely decorative instincts have determined the lines of higher architectural development in dry sunny climes. On the simple fundamental lines already described, great distinctive architectural styles have developed around the Mediterranean Sea, the nursery of western cultures.

The larger structures of the ancients, as in Egypt, Phoenicia, Mesopotamia, Greece, etc., had to be roofed by the employment of great stone beams supported upon forests of massive stone columns. The desirability of outdoor life with protection from the sun has led to the development in all these climes of arcaded courts and walks. Even in the simpler Saharan towns and oasis villages, such as Bisra and Ghardaia, the graceful colonnades relieve drabness with a touch of beauty and comfort. Only in the hottest spots in our Southwest, as in Imperial Valley, California, and in Yuma, Arizona, has this compelling need for protection from the sun resulted in modern arcaded sidewalks on the main streets, giving these towns individuality. Unfortunately, lack of unity in style and bad taste have generally negatived artistic effect. In the great Spanish Missions of the Southwest, too, the colonnaded courts were a feature which have been much copied, chiefly for artistic effect.

The mud dome accompanies simple types, but in Roman and later Romanesque architecture the great masonry dome was combined with columns and colonnades or arcades. Byzantine architecture, at its best in Sanctia Sophia, Istanbul, is distinctive for its delicate ornamentation of flat walls with small window space as well as for its peculiar style of dome. The Saracens added further modifications, as the horseshoe and pointed arch, creating a style which is at its best in the Alhambra.

Among the Indians of the Southwest, as among the Spanish and Mexicans, the simple arbor or ramada described before, or with more finish, the Mediterranean pergola, is a simple expression of the same need for protection from the

[16] J. W. Fewkes, 28th Report of the Bureau of Ethnology, 1906–07, pp. 33–179.

[17] Illustration, *National Geographic Magazine*, p. 360, Vol. 53, March, 1928.

sun, where little shelter is needed from the other elements and where outdoor life predominates.

American Construction in the Arid Southwest

The early American settlers in the Southwest were effectively isolated from their fellows and adapted themselves to the country. In this period, the latter half of the nineteenth century, American and Mexican villages were hardly distinguishable architecturally. Sometimes even the early white settler had to start his new home with a crude wattle shelter like those of the Indians. Even as late as 1877 the first Mormons, coming into southern Arizona and settling on the Salt River, had at first to imitate their Indian neighbors along the river, using the material close at hand. Some of these first shelters had one room with low dirt floor and walls of arrow-weed and poles plastered with mud. An old settler describes as follows the home of the first couple to be married in the settlement. "It was built on four cottonwood posts set in the ground and logs put across on top about two feet apart, covered in brush and straw so as to hold the dirt on the roof. There must have been ten or more wagon loads of dirt on the roof. The sides were boarded with lumber." This house probably originated as a simple brush shed through summer and with the coming of winter was transformed into a more sheltered affair. Prescott, the early capital and metropolis of Arizona, was different in its highland environment of cool climate and pine trees. Early writers described it as like a New England village. But not so the desert settlements, Tucson, Phoenix, Florence or Yuma. Even today the old adobe houses predominate in the older quarters, which have now become the Mexican quarters. These early settlements and settlers were effectively isolated from the culture and its materials whence they sprung. Of necessity they adopted the indigenous desert house and adapted themselves to the conditions found in the desert, much as the Indians and Mexicans had done before them.

Throughout the state of New Mexico, with its predominant Spanish and Mexican population, the villages are nearly all made up of the low one-storied rectangular mud houses. The church, with its earth or frame tower mounted by a cross, is always the dominant and only conspicuous structure of the village.

In the Salt River Valley of Arizona, which now includes about 30 per cent. of the population of the state on less than 1 per cent. of its area, three distinct periods of architecture are in evidence. Phoenix and Tempe were the only settlements of any importance in the valley in Arizona's early historical chapters, and even they in their earlier days were entirely subordinate to places elsewhere in Arizona. The old villages of Phoenix and Tempe were mostly of flat-roofed buildings. With the subsequent rapid settlement of the valley this type of architecture was entirely subordinated.

Following the building of the Southern Pacific Railway, which entered the state in 1878, there was an influx of settlers into the valley who came too rapidly to be assimilated by the indigenous culture. Swifter and cheaper transportation brought also building materials to which the new settlers had been accustomed, and a new period of lumber and brick construction was ushered in during the eighties.

However, this was before the day of general refrigerators and electric fans or of easy escape from the summer heat to the neighboring highlands by auto over smooth highways, and building construction had to be adapted to making the best of the long season of excessive heat. Winters were short and mild and made few demands and made possible lighter construction. Adequate facilities for heating, even in this sub-tropical

climate, were commonly neglected, the cheerful but inefficient open fireplace playing the principal rôle.

Most of the farm houses of the valley were built in this period. The inside arrangement of rooms on both sides of the wide hall was according to the conventions of the period, but the arrangements for outdoor sleeping with unscreened porches on one, two, three or all sides of the house was a conspicuous adaptation. High ceilings and attics protected the lower story or stories. The larger and better houses were built with two stories, but the typical house had one story with an attic, under a long square diamond roof sloping down over the screened porches on three or all sides.

In the town, roofs or porches commonly extended over the sidewalks, providing the best possible comfort to pedestrians and loafers. Hotels, like houses, provided outdoor sleeping quarters, and openly exposed sides and fronts were faced with verandas for each story. Each room had its door opening upon the sleeping porch, shared by all. Lack of privacy in sleeping quarters has never been immodest in Arizona, as considered in other parts of the country, and night dress was modest there long before the day of motion picture display and street pajamas. The street porch is for many of the older humbler village houses still the family sleeping room. The adaptations of this period were utilitarian but inartistic, with rusty screens and weather-beaten canvas shades on the porches, and the sidewalks covered with narrow roofs heterogeneous in height and angle, supported by slender posts or props. Yet there was an inviting hospitality about the old style house with its cool verandas and in the covered sidewalks, inviting to loiter and to loaf.

The modern metropoli of the desert, such as Phoenix, Tucson and El Paso, have developed rapidly in late years, along the most modern lines, chic, fresh and new, in imitation of the Southern California towns. The easy hospitality of the clime, expressed in their older styles, has given way to brisk commercialism. The sheltered sidewalks have almost disappeared. These cities would by their dress belie the summer heat, but what an opportunity is lost for individual expression of fitness to environment, both comfortable and artistic. There are local suggestions for pleasing, harmonious and utilitarian planning in the arcades and towers of San Xavier Mission near Tucson, in the terraced pueblos of the Indians and in the "Governor's House" of the Spanish period in Santa Fé. In the latter city there is much construction in imitation of the Spanish and the Indian pueblos but no concerted plan.

In these desert oasis cities of recent rapid growth there are rows of attractive appearing small homes built without regard to summer comfort in imitation of styles developed in other climes. However, the better-built homes now incorporate insulation wall materials, and the larger and better public and commercial buildings and hostelries have installed systems of air-cooling, permitting greater independence of form. So while in the future the desert climate will continue to impinge upon the evolving culture of the arid Southwest, the resultant distinctive qualities of the architecture may be more in the internal structure and in the use of special appliances rather than in the external expression of form.

FREEDOM OF THOUGHT IN ASTRONOMY

By Dr. OTTO STRUVE
DIRECTOR OF THE YERKES OBSERVATORY

On the 22nd of June, 1633—a little more than three hundred years ago—an old man, weakened by months of imprisonment and almost daily questioning, and whose eyesight was rapidly failing, knelt before a jury of ten cardinals who had been appointed by Pope Urban VIII, at the Dominican Church of Santa Maria Sopra Minerva, in Rome. A large assemblage of prelates and dignitaries of the official Roman Catholic Church had gathered for the occasion. The old man wore the black ecclesiastical gown of a professor and every one in the audience knew him, for he was the professor of astronomy at the University of Pisa and one of the greatest scientists of all ages, Galileo Galilei.

The meeting was a special one: he had been summoned for the public pronouncement of a sentence for the teaching of heretical and untrue doctrines. And as he knelt there on the stone slabs of Santa Maria Sopra Minerva, there must have entered his mind a picture of another great man of science, who thirty-three years earlier had been tried for the same heretical belief that the earth was moving around the sun instead of being in a fixed position. On the 9th of February, 1600, the philosopher and astronomer Giordano Bruno, of Nola, had been excommunicated and turned over to the authorities with the request that "the punishment be merciful and without shedding of blood." A week later he was publicly burned at the stake on the Campo di Fiora, refusing in his last moments the consolations of a priest who tried to hand him a crucifix.

The accusation against Galileo consisted of "holding as true a false doctrine taught by many, namely, that the sun is immovable in the center of the world, and that the earth moves, and is also with a diurnal motion." This doctrine was pronounced by the judges as "absurd, philosophically false and formally heretical, because it is expressly contrary to the Holy Scriptures. . . ."

Having been threatened with torture, Galileo was finally compelled to declare: "I abjure, curse and detest the said errors and heresies and generally every error and sect contrary to the said Holy Church; and I swear that I will nevermore in future say or assert anything verbally or in writing which may give rise to a similar suspicion of me; but that if I shall know any heretic or anyone suspected of heresy, I will denounce him to this Holy Office or to the Inquisition and Ordinary of the place in which I may be."

The story is told that when Galileo rose from his knees after having read the humiliating abrogation of the results of half a century of his work in astronomy, he murmured the famous words "E pur si muove!"—"Nevertheless, it does move!"

Galileo was released from the prison at Rome, but remained under the surveillance of the Inquisition, and his books, even those which did not deal with the Copernican system of the world, were prohibited and for many years could not be printed either in Italy or in any of the other Catholic countries.

Almost three hundred years after the trial of Galileo, in the year 1930, a self-appointed jury of twenty-one astronomers gathered in the offices of the Astrophysical Institute in Moscow and issued a proclamation, in the form of an open letter to Pope Pius XI at Rome. This, in effect, was as follows: He, the Pope, the infallible Vicar of Christ on earth,

is the direct successor in a line of twenty-four or twenty-five heads of the Catholic church, and is therefore responsible for the actions of his predecessors. Does he approve of and support the actions of Climent VIII, Paul I and Urban VIII under whose authority Giordano Bruno, Galileo and many others were persecuted, or will he openly denounce the actions of his predecessors "as being more vile than have been committed by all the criminals of the world together"?

The rôles had changed: the church is now the accused, and the astronomers sit as judges, but the nature of the accusations is startlingly similar. We note the same hostility, the same narrowness and the same intolerance in 1930 as in 1633!

And to make it clear that the attack was not directed merely against the Pope, the commentary to the letter states that "heretofore no one has dared to connect these acts (of inquisition, cruelty and terror) with that system of mental enslavement which is propounded by all churches, including the Vatican."

It is an established fact that in Communistic Russia, a country occupying a considerable portion of the surface of the earth and having a population of one hundred and fifty million, astronomy has been definitely charged with the task of destroying all religion. In observatory reports and in general articles in scientific journals we find that anti-religious propaganda has become one of the duties of an astronomer.

We might be inclined to ignore the anti-religious propaganda in Russia, were it not for the fact that this propaganda is systematically and persistently directed towards other nations. Thus in the *Russian Astronomical Journal* (Vol. 9, p. 125), we not only find an appeal to "all the scientists of the world" to "actively defend the Soviet Union" and to form a "close and steady alliance with the revolutionary proletariat," but we are told that in the capitalistic countries "the search for a synthesis degenerates into an appeal to religion, that is, to an illusory solution at the price of the capitulation of the scientific mind." Time and again the Soviet scientists are instructed not to "display a blind acceptance of the bourgeois authorities of America and of Europe," who fall into religious mysticism and are therefore unable to advance science.

It is astounding that after denouncing such men as Sir James Jeans, Erwin Schrödinger and others, for their "cowardly idealism," the spokesman for the Russian astronomers advises those who have not had the benefit of the class-war to guide them along the path of pure materialism, to develop their astronomical work along the lines laid down by such "authorities" as Lenin, Stalin and the father of the method of dialectic materialism, Hegel.

Lenin and Stalin are regarded by many as great statesmen and able economists, but it seems surprising that even their most loyal supporters would regard them as authorities in astronomy. To drag them into a field of science which they have never even attempted to study is as unreasonable as the dogmatic faith of Galileo's judges in the teachings of Aristotle!

Hegel, on the other hand, is well known to astronomers. In his famous philosophical treatise, "Dissertatio Philosophica de Orbitis Planetarum," he proved that there could be no planets between Mars and Jupiter and ridiculed the astronomers for their search of such objects. The number of planets, he stated, could not exceed seven, and he exposed "the folly of certain devotees of induction who sought a new celestial body merely to fill a gap in a numerical series."[1] Even while this "Monumentum insaniae saeculi decimi noni," to use the words of the Duke of Sachsen-Gotha, was being written, the Italian astronomer Piazzi discovered, on January 1, 1801, the first planetoid Ceres.

[1] Clerke, "History of Astronomy," p. 73, 1903.

It is amazing that after this colossal failure, Hegel is being thrust upon a pedestal for astronomers to imitate. I shall not quote here the opinions of two of his greatest contemporary astronomers, Gauss and Schumacher, but those who are interested will find a complete account in Wolf's "Geschichte der Astronomie" (p. 685, 1877).

The statement of the Soviet astronomers addressed to Pope Pius XI, though probably written and promoted by what we might call "political bosses" whose connection with pure science is less than casual, was signed by more than one hundred astronomers. Among them are men who are truly great and whose opinions can not be ignored. Whether we agree with them or not, whether we suspect that pressure has been exercised in obtaining their signatures, the fact remains that here is a large group of scientists who are avowedly opposed to all religion.

Under the circumstances, I can not agree completely with Dean Inge, who in his presidential address at the Conference of Modern Churchmen on "The Scientific Approach to Religion," held at Oxford in 1924, made the following statement: "The new desire for mutual understanding between science and religion, the weakening of the old dogmatics on both sides is a most happy feature of our generation." I am afraid that the "old dogmatics" have not been entirely outlived, and that intolerance, blind faith in authority and far-fetched accusations exist in 1933 as they did in 1633!

It might be thought that the recent outbreaks of hostility against religion in Russia and the even more recent outbreaks against Christianity in Germany are merely reflections of the post-war confusion which has upset the world since 1918. But that is not true. I quote from the book, "The Church and Science, a Study of the Inter-Relation of Theological and Scientific Thought," by Hector Macpherson:

> There can be little doubt that, speaking generally, science and religion were mutually hostile in the latter half of the last century. It is true that many of the greatest men of science were profoundly religious men; it is equally true that many leading churchmen . . . were broad and tolerant in their attitude to science, and were, indeed, sympathetic to scientific progress. Many scientific pioneers were themselves churchmen. While conceding this, the fact remains that the general attitudes of science and religion were wide as the poles asunder. The general belief was that the men of science, by finding natural explanations for such events as the origin of the earth, the origin of life and the origin of man, had driven God out of the cosmic process; and so the typical theologian rejoiced when scientific explanations broke down, and when scientists were divided among themselves. . . .

It might interest you to know that the author of this quotation is himself a minister in a church at Edinburgh, Scotland. A member of the Royal Astronomical Society, he has written numerous books on astronomy and related subjects. His book,[1] "The Church and Science," has been freely used in the preparation of this lecture, and I should like to recommend it to all interested persons for its sound and commonsense interpretation of many questions.

Although there has been an agelong controversy between astronomers and the church, it would be erroneous to conclude that astronomers have been predominantly irreligious. Galileo in a letter to his friend, Castelli, dated December 21, 1613, expressed his opinion as follows:

> As the Bible, although dictated by the Holy Spirit, admits in many passages of an interpretation other than the literal one, and as, moreover, we cannot maintain with certainty that *all* interpreters are inspired by God, I think it would be the part of wisdom not to allow anyone to apply passages of Scripture in such a way as to force them to support as true any conclusions concerning nature, the contrary of which may afterwards be revealed by the evidence of the senses, or by actual demonstrations.

[1] Published in 1927 by James Clarke and Company, 9 Essex Street, Strand, W. C. 2, London, as a part of the series "The Living Church," under the editorship of Professor John E. McFadyen, of Glasgow.

> Who will set bounds to man's understanding? Who can assure us that everything that can be known in the world is known already? . . . I am inclined to think that Holy Scripture is intended to convince men of those truths which are necessary for their salvation, and which, being far above man's understanding, cannot be made credible by any learning or by any other means than revelation. But that the same God who has endowed us with senses, reason and understanding does not permit us to use them and desires to acquaint us in another way with such knowledge as we are in a position to acquire for ourselves by means of those faculties, *that*, it seems to me I am not bound to believe, especially concerning those sciences about which the Holy Scriptures contain only small fragments and varying explanations. . . . I think that in discussing natural phenomena we ought not to begin with texts from Scripture, but with experiment and demonstration, for from the Divine Word Scripture and Nature do alike proceed.

Similarly, many other noted astronomers of all times have combined religion with science and have seen no self-contradiction in this attitude. Copernicus was a monk. Gassendi, a French-Catholic priest, announced some twenty years after Galileo's trial that he would have accepted the Copernican doctrine had it not been declared by the church to be opposed to Scripture. Cassini, the first director of the Paris Observatory, founded in 1667, did not declare himself in regard to the Copernican system. He and his successors were devoted Catholics and established a private chapel in the building of the Paris Observatory where a priest read mass in times of sickness in the family. The German historian and astronomer Zinner states that the majority of astronomers have been religious men; but the tendency at the present time is probably to drift away from the formal churches.

What, then, has been the origin of the controversy? Its roots lie buried in history. Astronomy, the oldest of the sciences, originated as a part of religion. In Egypt, where the sky is clear much of the time and where the stars are more striking to the eye than they are in northern latitudes, astronomy became intimately connected with worship. The god Re was associated with the sun, while the goddess Isis was symbolized by the bright star Sirius. Sirius is visible at this time of year[2] in the southwestern sky, after sunset. Later in the year, in May and June, the apparent western motion of the sun renders it invisible, and early in July it can again be seen, in the early morning just before sunrise. The Egyptian priests watched patiently, night after night, for the first appearance of Sirius in the morning sky. It served as a calendar for them, and indicated that the Nile might be expected to start its yearly flooding of the valleys, upon which the crops, and therefore the existence of the Egyptians, depended.

Thousands of years before our era the Egyptians had developed a conception of the universe unlike that of most other nations. To them the universe was like a shell, with the earth at the bottom and the sky above it. The earthward face of the sky was sprinkled with lamps, hung from cables, which were extinguished during the day. The sun was a disk of fire traveling on a riverboat around the world.

A somewhat similar conception of the world was held by the Chaldeans.

The Hebrew version of the universe is contained in the Book of Genesis. The earth is conceived as a flat disk surrounded by water. Above the earth is the firmament, a solid and transparent vault, allowing the light of the stars to penetrate, and above the firmament is a vault containing the "upper waters," from which come rain, hail, snow and wind. The sun, moon and stars are supported above the "upper waters." A thorough study of the conception of the universe in the Bible was made by the Italian astronomer Schiaparelli in a book entitled "Astronomy in the Old Testament."

[2] April, 1934.

The old Mosaic cosmology, as pictured in the Book of Genesis, remained the doctrine of the official church. However, as Macpherson remarks, two other doctrines were simultaneously held by the Christian Church in the Middle Ages. There was the Aristotelian theory, which conceived the earth as a spherical body located in the center of the universe. The various celestial bodies were imagined as being attached to transparent spheres revolving around the earth. Then there was the Ptolemaic system, which discarded the concentric spheres of Aristotle and assumed that the planets moved in epicycles. The theory of Ptolemy was astronomically far superior to the other two, but it seems to have been held by only a small minority of educated people in the Middle Ages. Thomas Aquinas and Roger Bacon had adopted it.

It is difficult to understand why the system of Aristotle should have been made almost a dogma by the church of that time. In many respects it contradicted the story of the Bible, yet it does not seem to have met with much opposition when it was introduced into Europe by the Arabs. As Macpherson puts it, "The only bond of agreement between the three conceptions was the supreme and central place which each of them assigned to the earth."

This idea was badly shaken by the work of Copernicus. By abandoning the central position of the earth he was able to simplify the theory of Ptolemy and to free it of the complications produced by the epicycles. Though started thirty years earlier, the great work of Copernicus, "De Revolutionibus Orbium Coelestium," was not published until 1543, the year of his death. He was afraid of the reception it might receive on the part of the church.

However, neither he nor his great successor Kepler seem to have been molested for their cosmological ideas, though both the Catholic and the Protestant churches rejected them. Martin Luther referred to Copernicus as "an upstart astrologer, who strove to show that the earth revolves, not the heavens or the firmament, the sun or the moon. . . . His book wishes to reverse the entire science of astronomy; but sacred scripture tells us that Joshua commanded the sun to stand still and not the earth." Melanchthon and Calvin made similar remarks: "Who will venture to place the authority of Copernicus above that of the Holy Spirit?"

The controversy was enhanced by the epoch-making discoveries of Galileo. In 1608 an apprentice working in the optical establishment of Hans Lippershey in Holland was playing with some spectacle lenses and happened to look through two of them held a certain distance apart. He noticed that objects seen through the lenses appeared enlarged and reversed. A few months later Lippershey was given a reward of 900 florins for the discovery of the telescope.

In 1609 vague reports of the Dutch discovery reached Galileo in Italy, and after some experimenting he succeeded in rediscovering the principle of the telescope. In the same year he began his astronomical observations.

To his great surprise he found that the moon was covered with mountains and that the planets appeared as tiny disks, while the stars were greatly increased in number, but were not noticeably increased in size. The discovery of four moons traveling around Jupiter was especially startling and gave a visible miniature of the Copernican system.

It was on January 7, 1610, that Galileo turned his telescope on Jupiter and noticed three fairly bright stars in a line with the planet, two of them being to the east and one to the west. On the following evening all three were on the west side of Jupiter.

The significance of this discovery is brought out by the following words of Galileo:

> We have a notable and splendid argument to remove the scruples of those who can tolerate the revolution of the planets around the sun in the Copernican system, yet are so disturbed by the motion of our moon about the earth, while both accomplish an orbit of a year's length about the sun, that they consider that this theory of the universe must be upset as impossible; for now we have not one planet only revolving about another, while both traverse a vast orbit about the sun, but our sense of sight presents to us four satellites circling about Jupiter, while the whole system travels over a mighty orbit about the sun in the space of about twelve years.

Galileo referred here to the system of Tycho Brahe, the last of the great observers before the invention of the telescope, who postulated that the planets moved around the sun, but that the latter revolved around the earth, which was fixed in space.

Galileo's discoveries were immediately attacked on all sides. The moon could not possess mountains, it was argued. Sizzi, an astronomer in Florence, denied the existence of the moons of Jupiter, because of the sacred nature attached to the number seven: did not man possess seven windows in his head? "Moreover," he states, "these satellites of Jupiter are invisible to the naked eye and therefore can exercise no influence on the earth, and therefore would be useless, and therefore do not exist; besides the Jews and other ancient nations, as well as modern Europeans, have adopted the division of the week into seven days, and have named them after the seven planets (Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn). Now, if we increase the number of planets, this whole and beautiful system falls to the ground."

Sizzi and others refused to look through the telescope, probably fearing that they would be deceived by some diabolical trick.

No less severe were the attacks upon Galileo's discovery of sun-spots. The fact that the sun was not uniformly brilliant seemed to upset the idea of the perfection of the exterior universe, which was one of the basic principles of Aristotle.

The sun-spots were independently discovered by the Jesuit priest Scheiner, and Macpherson relates that when Scheiner announced his discovery to the provincial general of his order the latter replied:

> I have read the whole of my Aristotle several times, and I can assure you I found nothing similar there. Go, my son, quiet yourself, and be certain that there are defects in your glasses or in your eyes which you take to be spots on the sun.

In spite of the opposition of the church the Copernican system was soon generally accepted. Officially the books of Nicolaus Copernicus remained prohibited until 1822.

The Copernican system found its greatest support in the theory of gravitation of Newton, published in the middle of the eighteenth century. The universal force of attraction, which acts equally on the earth, the sun and the stars, provided the clock-work which was required to keep the planets moving in accordance with the famous three laws of Kepler. But Newton was unable to account for the origin of the motions. Gravity could maintain them, but could not start them. Newton thought that God had arranged these motions and that He from time to time intervened in order to correct the irregularities which arise by the actions of planets and comets upon one another.

This view received a setback when Kant, Laplace and Herschel advanced the nebular hypothesis of the origin of the universe. They attempted to show that the motions in the solar system had developed gradually as the result of the continuous action of physical laws upon a chaotic nebular mass. The idea of a primitive creation as imagined by Newton was thus rendered unnecessary, though no attempt was made to account for the original nebula.

No wonder that "throughout the theological world there was an outcry at once against atheism, and war raged fiercely."[3]

Nevertheless, the ideas of Laplace and Herschel were later developed by other astronomers, and cosmogony now constitutes an important part of astronomy.

It is, I think, clear to us now that the long-enduring war between the church and astronomy was due to misunderstanding. Had the spheres of science and religion been properly divided in the days of Galileo, there would have been no discord.

In conclusion, we might ask whether the history of astronomy gives us an indication of its future. The errors made by theologians and astronomers of the past, though glaring when seen in the light of present-day knowledge, were the result of the chaotic state of civilization in the Middle Ages. There is no doubt that the men on both sides of the controversy were honest and were genuinely following their convictions.

Is it not possible that we, in the twentieth century, are prone to repeat the mistakes of our ancestors of the seventeenth century? Should we not profit from their experience and urge upon a world distracted by the economic evils following the great war, and tending towards extreme chauvinism, that *only tolerance and respect for the opinions of others can save us from a repetition of the mistakes of the past?*

It seems to me that this is the only conclusion in which we are justified. Astronomy does not undertake to dictate what nor how we should believe. It is not directly concerned with religion, but leaves the astronomer free to form his beliefs as would a member of any other profession. Having made this concession, he has a right to expect that his freedom of thought will not be interfered with by political, religious or other non-scientific interests.

His work consists of the search for truth, and he should not permit prejudices to inferfere with the freedom of his mind. He may, if he wishes, search for law and order in the universe, but he should not presume that absolute order must necessarily exist. He may marvel, if he likes, at the beauty and intricacy of the structure of the galaxy, but he should not assume in advance that there *must* be either beauty or intricacy. Laymen often speak of the "purpose" evidenced in the astronomical universe. An astronomer is justified in attempting to find whether the stars really give evidence of a purpose comprehensible to our minds. But remembering the successive steps of Gassendi, to whom the Copernican system was unacceptable because it did not comply with the Scripture, and of Newton, who evoked the remark by Leibnitz that his world-system appeared to be like a clock which required the frequent interference of the watch-maker, the astronomer would do well not to start out with the preconceived idea that he is bound to discover an understandable purpose or a universal power in the galaxy.

At the same time, no one knows better than does the modern astronomer that our knowledge of the material universe is limited on all sides. Recent work on the "Expanding Universe" by Slipher, Hubble, Eddington, DeSitter, Einstein and Lemaître has brought us to what now seems to be a wall. What lies beyond the wall and what may be concealed within the idea of a curved universe is for the present a mystery.

[3] A. White, "Warfare of Science with Theology," I, p. 18.

THE THIRTY-HOUR WEEK

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AMONG the many remedies which have been proposed to overcome the depression none is more far-reaching in its potential effects upon the welfare of the people of the United States than a thirty-hour week in industry. It is safe to say that no legislative proposal has ever been advanced which is more revolutionary in its economic and social implications. Its appeal to the public is based on the universal desire for immediate recovery, and for greater security of employment in the future, with more leisure in which to enjoy life.

A higher standard of living—with more goods and services for everybody and more time in which to enjoy them—has long been the goal of society. Great progress, moreover, has been made in this direction during the past few generations. In the thirty-year period from 1900 to 1929 the working hours in American industry were reduced on the average from about 57 to approximately 50 hours per week. While this 13 per cent. reduction in the length of the working week was occurring, there was a rise in the per capita income of the American people of approximately 40 per cent. All classes shared in this improvement.

Important as has been this gain, few would be satisfied with the results thus far attained. The goal for the years which lie ahead should be a rapidly increasing productive efficiency which would make possible still further reductions in hours and a more abundant distribution of goods and services for the satisfaction of human wants than has ever been accomplished in the past. Everybody cherishes the same goal; differences of view arise chiefly in connection with the ways and means by which recovery and continued economic progress are most likely to be achieved.

In view of the fundamental character of the proposal for a thirty-hour week it is not surprising that many people have looked upon it with serious misgivings and attacked the very premises on which it is based. It has become, in fact, a primary national issue. It is therefore important that an analysis of the economic implications of the problem be made at this time. Would it bring the material benefits which its advocates believe, or would it precipitate new difficulties and further lower already reduced standards of living?

THE BACKGROUND OF THE MOVEMENT

The thirty-hour week proposal was advanced before the coming of the Roosevelt administration. In fact, bills had been introduced in the preceding session of Congress in the form of measures to prevent interstate or foreign commerce in products of industrial enterprises in which workers were employed more than five days a week or six hours a day. These bills, however, as well as those introduced by Senator Black and Representative Connery in the spring of 1933, did not definitely propose the maintenance of existing weekly wages. These measures simply sought to compel a wider distribution of whatever work existed and were in line with the "share the work" movement which had attained some importance as a volunteer program.

The Black Bill passed the Senate by a vote of 53 to 30 on April 6, 1933. The Connery Bill, which varied only slightly from the Black Bill, failed to reach a vote in the House—being replaced by the measure for national industrial recovery. The coming of the Recovery Administration shifted attention from a uniform reduction of hours to such varying limitations of the work week as might be achieved through industrial codes.

A new bill, however, was introduced by Representative Connery in the 1934 Congress, which provided that all NRA codes should be subject to the thirty-hour week—which would mean a reduction of about one fourth from the average which had been obtained under the codes. A provision was also incorporated for the maintenance of existing weekly wages. It is the principle of the Connery Bill that is now under public consideration. It is likely to reach the stage of active legislative discussion in the coming session of Congress.

The Underlying Philosophy

The philosophy underlying the thirty-hour week is rooted in part in conditions arising in and growing out of the depression, and in part in certain fundamental assumptions with respect to the existing state of development of the economic system. The primary ideas may be briefly indicated.

The relation of the thirty-hour week proposal to the problems presented by the depression involves two distinct phases or aspects. At first, it was looked upon as a way of alleviating the distress of the unemployed. In the absence of any comprehensive governmental program of relief, and with private charity incapable of caring for the situation adequately, the spreading of employment was regarded as a means of meeting the crisis. Under this share-the-work plan, the burden of helping one's fellows would be borne directly by those whose hours of work were shortened.

Later, it was argued that the thirty-hour week might be made the means of breaking the depression itself. To accomplish this result it would be necessary to reduce the working week without an accompanying reduction in pay. A shorter working week, it was reasoned, would thus not only absorb unemployment but, by increasing aggregate payrolls, would expand purchasing power and help in a powerful way to "prime the industrial pump."

In its longer-run aspects the thirty-hour week was conceived to be possible, if not indeed essential, in the light of the great productive capacity which this nation has developed. The attention which so-called "technological unemployment" had attracted even before the depression gave rise to the thought that if we were to avoid permanent unemployment on a large scale it would be necessary to absorb displaced labor by progressively shortening the hours of work. Tremendous emphasis was given to this aspect of the problem by the assertions of the "technocrats" that the country's productive capacity is even now superabundant and that if given a chance it will soon render human labor largely obsolete.

The conclusion has been drawn from such discussions as these that this country has passed from an era of scarcity to an era of potential plenty; we now have, it is widely believed, a "surplus economy." The primary source of our economic difficulties, according to this conception, is excess productive capacity. A shorter week is thus regarded as desirable as a means of bringing about a better adjustment of supply and demand.

The thirty-hour week is also not unnaturally advanced as a means of furthering the cause of labor as a special group. A reduction in working hours,

rendering labor more scarce, would, it is believed, improve the bargaining position of employees and enable them to obtain progressively higher wages in the future. This, it is argued, would promote a better social order—through a better distribution of income. It is believed that scarce labor and high wages would prevent excessive profits and provide the larger income for the masses which is essential to the full utilization of productive capacity.

Analysis of the Underlying Philosophy

In considering the basic ideas underlying the thirty-hour-week plan it is necessary to break the discussion into two parts. It will be useful if we consider first the fundamental assumption that this country is suffering from a chronic state of over-production.

How great is our productive capacity? The Brookings Institution has recently made an exhaustive investigation of the productive capacity of the United States and the relation of this capacity to the consumptive demands and wants of the people.[1] The conclusions may be very briefly summarized.

In 1929, the last year before the depression set in, the actual output of goods and services had a value of approximately 81 billion dollars. The possible output—with the organization of economic activities then prevailing and with the capital supply and labor power then available—was approximately 97 billion dollars worth of goods and services. In making this estimate account was taken of the numerous practical considerations which operating industry has to face, such as seasonal factors and the requirements of changing styles. This figure, then, represents the practical capacity under the economic organization then existing.

Was production adequate to supply satisfactory living standards? If distributed equally among the entire population, the 1929 production would have given to each person goods and services valued at about $665. Had we been able to operate at 100 per cent. capacity, the income per person would have been increased to about $800. Income, however, is not divided equally. In 1929 there were over 2,000,000 *families*, having incomes of less than $500; this amount had to support two or more persons—an average of at least four. There were about 3,800,000 families with incomes between $500 and $1,000, and more than 10,000,000 families with incomes from $1,000 to $2,000. As many as 16,354,000 families, or more than 60 per cent. of the total number, had incomes under $2,000. A family income of $2,000 scarcely provides for the basic necessities of life, and leaves little or nothing for comforts and luxuries.

Even if the total product of the nation were divided equally among the entire population, the average family income would have fallen short of the requirements of a wholly satisfactory standard of living. What we must have in the future is a much larger production of goods and services than we have ever attained in the past, if we are to realize the aspirations of the people.

How would the thirty-hour-week affect wealth production? It has already been pointed out that during the great period of technological advancement from 1900 to 1929 we succeeded in increasing per capita production by about 40 per cent. and in decreasing the working week by about 13 per cent. In 1900 the standard working week of wage-earners averaged approximately 57 hours. By 1909 the average had been reduced to about 55, and by 1919 to about 51.3 hours. During the decade of the 20's there was further gradual reduction, and by 1929

[1] See Edwin G. Nourse and Associates, "America's Capacity to Produce"; and Maurice Leven, Harold G. Moulton and Clark Warburton, "America's Capacity to Consume."

an average of about 50 hours was reached. There was, however, a wide variation among the different divisions of industry, running from around 44 hours in coal production and the manufacture of men's clothing to as high as 60 hours in some divisions of the iron and steel industry.

Since 1929 the standard working week has been reduced to an average of about 40 hours. The greater part of this reduction occurred prior to the NRA and resulted merely from the decrease in the average hours actually worked as operating schedules were curtailed. Under the NRA these shorter hours came to be incorporated, with modifications, in the various codes as the standard week. It appears, then, that there has been a reduction since the beginning of the depression by about 20 per cent., or substantially more than had occurred in the previous 30 years. The proposed further reduction to 30 hours a week would mean a total reduction for wage-earners[2] since 1929 of 40 per cent.

The question presents itself squarely —Can we maintain a level of production equal to that of 1929 on a 40 per cent. shorter working week for the major portion of American workers? It is evident that such a maintenance of output would be possible only provided there has been a corresponding increase in productive efficiency during these years.

Available data indicate that there was in fact an increase in man-hour productivity in *manufacturing industries* between 1929 and 1934 in excess of 25 per cent. This was in some cases the result of improved operating methods and more efficient machinery. But it was more largely attributable, we believe, to two other factors which are temporary in character. The first was the spur to efficiency resulting from the fear of losing one's job when jobs were scarce; the second resulted from a selective process in connection with personnel which gradually took place as the older, less efficient and less well-trained workers were removed from payrolls as the depression developed. Another contributing factor was the disappearance of a large number of relatively inefficient business establishments. Just as soon as the less efficient personnel was reemployed, man-hour productivity would doubtless register a sharp decline. Only that increase which resulted from technological progress could be expected to remain permanent.

It is hardly to be believed that a comparable increase in man-hour productivity to that shown in manufactures has occurred in most other fields. In agriculture, transportation, building construction and the professional and domestic services, it does not appear that there has been an appreciable increase in productivity resulting from technological improvements. Such increase in man-hour output as has occurred in these lines is largely attributable to the temporary influences to which reference has been made.

Manufacturing industries account for only about 20 to 25 per cent. of the value of the total national output of goods and services. Hence, even if we assume that the recent increase in man-hour output in manufacturing lines were to be wholly maintained, the average increase in productivity in American economic life as a whole would appear to be less than 10 per cent.

We conclude that a reduction in the hours of work such as is contemplated would inevitably mean a volume of wealth production substantially below the levels obtaining in 1929. But it should be emphasized again that what this country needs is not less production but more.

[2] For salaried workers the reduction since 1929 has been much less. At present the average standard week for wage-earners in industries operating under codes is practically the same as that for salaried workers.

Would a better distribution of wealth be the result? One of the underlying ideas of the thirty-hour week, it will be recalled, is that it would make labor scarce, raise wages and thereby bring about a more equitable distribution of national income. We have just seen that the consequence would be a reduction in the total product to be divided. Assuming that a more even distribution of a smaller total income is preferable to a less uniformly distributed larger total which affords higher incomes for all, the question must still be raised whether the thirty-hour week would actually bring about a more even distribution of the national income.

Superficially, it may appear that if wage rates are increased the share of the total product going to the workers would rise and that the share going to profits would decrease. But the problem is not so simple as this. Rising wage rates increase costs and prices and when prices rise the relative share going to profits may be maintained or even increased. The experience under the NRA does not support the assumption that an increase in wage rates, resulting from shorter hours, increases the proportion of the total output of industry going to the masses. The relation of the increase in wage costs to prices will be discussed presently.

We now turn from these longer-run considerations to the relation of the thirty-hour week to the problem presented by the depression itself. We must consider first the desirability of a shorter working week for the express purpose of spreading employment and thereby alleviating distress.

Is a shortened working week a satisfactory means of relief? A reduction of the working week to 30 hours is certainly one method of taking care of the relief problem. In round numbers we have 30 million employed workers and 10 million unemployed. If we assume that the work week is reduced from 40 to 30 hours every unemployed worker could presumably be given 30 hours of work.[3] Since those to be brought in to share the work of those now employed would on the whole be less experienced and less efficient for the particular tasks in hand, their reabsorption in industry by means of the thirty-hour week would obviously mean a decrease in total industrial output and in the volume of goods and services available for supplying the wants of the people.

Other methods, or combination of methods, for affording relief are clearly superior to spreading employment. They are on the whole beset with fewer practical difficulties, they are more equitable and they do not lead to a reduction in total product. Any method of relief which provides new employment without interfering with the volume of output of those already employed has the positive advantage of adding to, rather than subtracting from, the total production of goods and services.

Would the thirty-hour week generate recovery? In addition to reabsorbing the unemployed, the shorter work week, as we have seen, has come to be conceived as a means of increasing total purchasing power and thereby stimulating business revival. The argument, in brief, is that the increase in total payroll disbursements would lead to increased purchases in trade channels, which would start the wheels of industry everywhere.

Conceding for the sake of the argument that the purchasing power theory of business recovery is sound, we must nevertheless ask whether an expansion of purchasing power by means of the thirty-hour week is a feasible means of

[3] The average number of hours actually worked by those employed, including part-time workers, is now less than 40 hours. Consequently, the spread of employment would not be as balanced as is suggested by the round figures here cited. It should be noted, however, that a 30-hour standard week would in practise mean an average of less than 30 hours of actual employment.

accomplishing the desired result. It should be clear from the analysis already made that a thirty-hour week would involve a simultaneous increase in wage rates and a decrease in productive efficiency. The volume of output would be declining at the same time that the payment of wages was increasing. This would perforce result either in bankrupting business or in a rise in prices more rapid than the expansion of payrolls. If the former alternative resulted, we obviously would not have recovery, but rather greatly intensified depression. In the latter alternative the rapid advance in prices would nullify the increased money wages.

In considering the relation of a reduction in hours to recovery, the inflexible character of the thirty-hour week must not be forgotten. Different lines of industry ordinarily have varying work schedules—adapted to the character of the labor involved, the arrangement of the machinery and the requirements of different processes of production. A rigid universal thirty-hour week, or for that matter any other set number of hours, would put industry in a straightjacket and reduce efficiency. Even though in time business might possibly accommodate itself to an inflexible working schedule, the immediate effect would unquestionably be to retard recovery.

The Thirty-Hour Week and the Level of Prices

It is reasonably clear from the preceding paragraphs that a sharp increase in wages, accompanied by a decrease in average efficiency, would exert through increased costs a direct effect upon prices. Let us see just how great an increase in wage costs is implied. Under the NRA codes the average "standard week" in industry is about 40 hours. Assuming this standard to be the basis for computing weekly wages when the hours were reduced to 30, an increase in hourly rates of wages by 33⅓ per cent. would result. If, however, the measure were applied on the basis of the actual hours worked at the time it took effect the average increase in wage rates would be somewhat less. This is because the actual length of the working week for industry as a whole is now appreciably less than 40 hours.

It is unnecessary to speculate as to the probable effects of such an increase in wage costs upon prices—for we have before us the comparable experience of the NRA. A study which the Brookings Institution has made of the effect of wage increases upon prices since the establishment of the codes shows that the prices of manufactured commodities and the wage rates of the labor engaged in the production and distribution of these commodities had roughly an equivalent increase.[4] Whether or not one thinks so extensive a rise in prices was warranted, it is none the less a fact; and it is a fact which has already apparently led to a material shift in point of view on the part of the Administration itself as to the practicability of the policies that have been pursued.

In the light of this experience, it would seem reasonable to believe that a further drastic curtailment of the working week would be followed by a commensurate increase in the prices of manufactured commodities. Indeed, in consequence of the decrease in average efficiency that would ensue, the rise in prices might well be more pronounced than was the case under the NRA codes.

It should be noted, however, that instead of recouping by means of an immediate rise in prices many business concerns might be confronted with serious immediate difficulties. In cases where prices could not be raised in anticipation of the increased costs, and where working capital is limited, it would be necessary to procure the funds

[4] "The NRA as a Recovery Measure," by George W. Terborgh (to be published in the near future).

with which to meet the enlarged payrolls by means of bank loans or the flotation of securities. It is scarcely to be doubted that the difficulties encountered during the past year, particularly in small industries, in procuring the funds necessary for increased operating costs would be greatly intensified by the establishment of a thirty-hour week.

Effects upon the Various Economic Classes

Assuming that the thirty-hour week could be installed on a national scale without throttling enterprise, it remains to trace its consequences. We shall consider first the effects upon various groups in the body politic and, second, its relationship to other phases of national policy.

1. *Wage-earners.* The thirty-hour week has been advanced primarily in the interests of the laboring class as a whole. Let us, therefore, consider just how it would affect the wage-earners. At first glance it would appear that, since there would be no cut in wages, the position of the worker who is employed would in no wise be impaired. The truth is, however, that his real wages would be appreciably reduced in consequence of the rise in prices. Everything that he purchased which was produced by industries operating on the thirty-hour week schedule would, as we have seen, be substantially enhanced in price. Moreover, there would be a tendency, for reasons already indicated, to freeze standards of living at the reduced level.

The special effects upon different wage-earners will depend upon the method used in establishing the plan. At present there is a great variation in working hours among individual employees, different plants and different industries. Thus, according to September, 1934, figures, the average in meat packing was about 43 hours per week, while in iron and steel it was less than 23 hours. If the measure were applied indiscriminately on the basis of the actual hours worked at the time it took effect, the workers in meat packing would obtain an average weekly wage based on 43 hours of work with added leisure of 13 hours, while those in iron and steel would presumably be left with average wages for a 23-hour week, with no possible increase of leisure.

2. *Salaried and fixed income groups.* It is not clear from current discussions whether the thirty-hour week would be made applicable to individuals working on salaries in industry and other occupations. If it did apply to them they would be affected in much the same way as wage-earners. They would have more leisure, but this would be at the cost of a lower real income. If the thirty-hour week were not applied to this class, they would have the lower standards of living without an increase in leisure. Individuals living on fixed incomes would be adversely affected to the precise extent that prices rose.

3. *Farmers.* The 30 million people constituting the agricultural population would likewise be adversely affected. It is hardly to be expected that those who are pressing for this measure contemplate a thirty-hour week for the farmer. Although the farmer would thus not get any more leisure, he would find himself confronted with higher prices for all the commodities he has to purchase. The rise in prices would affect him both as a consumer and as a producer. The rise in his operating costs would reduce his money income, and the purchasing power of this money income would also be curtailed as a result of the rising level of prices.

It should also be pointed out that certain types of industries would be adversely affected. Regulated industries, such as the railroads and public utilities, would be unable quickly to advance prices as wage rates and costs of pro-

duction increased. In consequence, earnings would be naturally reduced; and in view of the slender margin of profits now existing we might well expect a new epidemic of bankruptcies. In any event, it would prevent such industries from contributing toward recovery by increased expenditures for replacements and new equipment.

Relation to Other National Policies

Consideration must also be given to the possible effects of the thirty-hour week upon the government's program in general. Would it supplement other policies now being pursued, or would it tend to impede the national program of recovery?

First, the proposal obviously works at direct cross purposes with the government's agricultural program. The effort is being made to bring about a better adjustment between agriculture and industry through raising the prices of farm commodities relatively to the prices of industrial products. If the thirty-hour week were instituted, it would certainly defeat this objective.

Second, a thirty-hour week would tend to impede international commerce at a time when the United States is making a renewed effort to expand foreign trade. At this very juncture we are entering into negotiations with various foreign countries with a view to consummating arrangements for reopening the channels of international commerce—as a means of promoting world recovery. A sharp increase in American wages would be accompanied by an immediate demand for higher tariffs as a means of protecting the American market from a vast increase in imports of cheaper foreign goods; and as a practical matter all chance of effecting any adjustment of tariff rates by negotiation would be gone. In any case, the rise in costs and prices would increase the difficulties of American manufacturers in finding outlets abroad. Such a policy would thus work against a growth of exports and the increase of employment connected therewith.

Finally, it should be noted that this program ignores the experience gained under the NRA—with reference to the control of purchasing power, the safeguarding of the position of smaller industries, and the problems of regulation generally. In fact, the administration and enforcement of a thirty-hour week for industry generally would present far more intricate and baffling problems of policing and control than any yet encountered.

In summary, this analysis of the economic effects of the thirty-hour week clearly leads to the conclusion that the measure would not promote national welfare. It would prove detrimental to the interests of labor as well as other classes. It would not promote recovery and bids well to intensify the depression. At best its immediate effects would be a spread of employment at the expense of efficiency and productive output. In its long-run implications the measure offers to the workers of the country merely a choice between more leisure and a more abundant consumption of goods and services.

It goes without saying that it is the duty of the nation to prevent want among the unemployed. But to seek this end by a compulsory reduction of the hours of work, which would freeze the possible volume of production below the level required to give all the people the abundance they desire, is as short-sighted as it is lacking in understanding.

NATURALISTS OLD AND NEW

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I

LYELL, Davy, Faraday, Darwin, Pasteur, Helmholz, Galton—merely to list these and other great naturalists of the nineteenth century suggests the discoveries and the methods of thought which make living in the year 1934 more free, effective and happy than living in the year 1800. These men and their like literally have shaped what is finest and strongest in contemporary intelligence. Nothing, however, is more characteristic of these naturalists than their recognition that time would probably disclose flaws in their work. So we may feel sure that, were they living now, they would eagerly and hopefully examine what the Encyclopedia Britannica terms the "new" naturalism, and all the more because this outgrowth of the past thirty years points to remedying a flaw that pervades the older naturalism they followed and taught.

This flaw is well exemplified in Huxley's well-known essay, "Ethics and Evolution" (1894). Its theme is that man is at cross purposes with the "cosmic process" or nature. Man's "ethical purpose" is to establish a society where justice, peace and kindliness flourish. But his utmost efforts can only fence off a little garden within nature's measureless, menacing jungle, whose law is pitiless force. So man's progress, insists Huxley, lies not in imitating nature, but in fighting her. In the long run nature wins; but man must "play the man," never yielding, and finding his solace in the memory of noble deeds. Bertrand Russell's "The Free Man's Worship" (1923) almost repeats Huxley's thought of thirty years before.

A "new" naturalist, if at all versed in anthropology, must smile at Huxley's notion that man's social aims are inherently opposed to the method of nature. For it is through establishing justice within his society that man rises to be master in nature's "jungle." "Morals" that diminish power are unethical rather than unnatural. Upon the play of other natural forces man's social intelligence simply imposes a new "dimension," which is as "natural" as a flower or an earthquake.

In general terms, the "older" naturalism contrasts nature with man, and tends to stress the "aberrations" of man's make-up and outlook; of his emotions, his arts, his schooling, his traditions and his society. It thought of man's "mind" as "epiphenomenal"—looking from outside upon nature—"the external world." It demonstrated only the "*Descent* of Man." It stands in contrast with that humanism for which "the proper study of mankind is man," and which proclaims "there man begins where nature ends."

On the other hand, the "new" naturalism finds a synthesis and culminating of natural agencies in man's achievements, which mark the *ascent* of man in nature; it finds man's "mind" to be a unique mode of interaction between an attentive body and the rest of nature, itself a part of nature and, with all its aberrations, as "natural" as anything else. It stands in contrast not only with humanism but with every attempt to identify nature with merely physical

nature or with any other single mode or factor of nature.

W. L. Bragg approaches the "new" naturalism in his recent lecture at Cornell.[1] "We must think of the physical world around us as the footprints of something which exists in other dimensions as well, which has other qualities which are not physical and which no physical apparatus, however delicate, can measure" (p. 240). But Bragg falls short of the new insight when he says,[2] "history only exists as a record of miracles. . . . Apart from the miraculous, history and time have no meaning except as a system of labels" (p. 239). To him, evidently what is not physically intelligible is unintelligible—miraculous!

The application of intelligence and the appropriate scientific method to all that history records, with the consequent elimination of the "miraculous," and the indefinite broadening of scientific study to every factor in every event in nature, is, says John Dewey, in the succeeding article of the same issue of *Science*, "The Supreme Intellectual Obligation." This recognition of the plurality of factors in natural events, and the potential intelligibility of all of them in their relation to each other is the keynote of the new naturalism. All knowledge is knowledge of nature, it is natural knowledge; though there are many kinds of knowledge.

The older "naturalists" are great specialists who uncritically accept philosophical or religious accounts of man's mind and will which have long been current. As Dewey notes, our present social confusion is very largely due to this disregard by specialists of the broader aspects of nature. Social regeneration calls for less restricted scientific activity and for a sounder philosophy. In consequence the "new" naturalists are perhaps best known as philosophers or as scientists with a pronounced philosophic bent. I refer to such men as C. L. Morgan, S. Alexander and J. S. Haldane in England, and L. J. Henderson, H. S. Jennings, A. N. Whitehead and John Dewey in this country. But all these men have attained competence, and most have attained high distinction in some field of natural science. The new naturalism is no more philosophic than the old; but it expresses a self-conscious, critical and technically competent philosophy instead of one that is largely traditional.

Practically, what difference does it make whether we side with the older school of naturalism, represented by such men as Bertrand Russell, E. L. Thorndike, A. S. Eddington and J. L. Milliken, or with the newer school in which Sir James Jeans apparently has just enrolled,[3] with W. L. Bragg as an illustrious candidate for admission? Here my answer is restricted to a few definite examples, in which the older school, through their exclusion from nature of factors existent in nature, commit what has been called the fallacy of reduction, or the fallacy of "nothing but." Its consequences are not merely theoretical.

In his "The Modern Temper" J. S. Krutch rightly traces current pessimism in part to the view that ultimately nature is nothing but physical elements blindly moving under inflexible law. Krutch himself seems to accept this

[1] "The Physical Sciences," W. L. Bragg, *Science*, March 16, 1934.

[2] *Ibid.*

[3] The 1933 edition of "The Mysterious Universe." However, Jeans' presidential address to the British Association for the Advancement of Science, printed in *Science*, Sept. 7, 1934, shows clearly that, while he has now heard that "mind" is an activity in nature, he has not at all grasped the realistic consequence of this fact. His conviction that "mind" knows only its own ideas is exactly the idealism of Bishop Berkeley, in 1710.

view, disregarding the many factors in nature other than these elements. This view is, according to my observation, largely traceable to the false simplification with which is "explained" so "miraculous" a fact as the formation of water out of the gases O and H. The average college student accepts without question the suggestion that somehow water is "nothing but" H and O combined in certain proportions. A path toward making this "miracle" intelligible is taken when we emphasize that the properties of any physical unit are not simply located in that unit, but are the properties of the interaction and interrelation between that unit and the rest of nature. In this way the matrix, structure and disposition of nature are given due weight in physical science, so that a path is left open to rendering the actual wealth and variety of the cosmic process intelligible instead of "miraculous" and alien.

A second illustration is found in attempts, since the days of Clerk Maxwell, to reduce the processes of nature to simple thermodynamic terms. In most natural events we see going on at the same time both development and degeneration. In the former, as the historian of nature records it, complexity of organization and heterogeneity of material increase; while in the latter they decrease. Consider, for example, the development of a solar system or of our earth or of a living body. In each case degenerative processes also may be found; and at some stage in every development degeneration takes the upper hand. But in nature as a whole, or in any part of it, it is impossible to say that either development or degeneration prevails.

Now, in physico-chemical equations the degenerative processes alone are described. If the developmental processes, such as the building of animal tissues, are some day subjected to such mathematical analysis, we have every reason to expect that they will exhibit not a diminution of available energy, but an increase.[4] There is, therefore, no present reason to declare that the "universe" is "running down" or to inquire how at some time it was "wound up." The most eminent astrophysicists, none the less, observing in the universe nothing but the type of change they have learned to "mathematize," have filled books, newspapers and lecture halls with tales of nature "running down." The effect is to discourage the application of scientific method to the "developmental," vital aspect of life, since these are thus ignored by leaders in science; and so the solution is undertaken by clergymen! To the "newer" naturalism the developmental processes are as natural and obvious as the degenerative. The problem is simply how to formulate the former processes mathematically. If it is shown some day that their "mathematization" is impossible, the fact that *developments* actually and observably occur must remain as an ultimate fact in nature.

In his "Principles of Psychology," in his chapter on "Association," William James laid it down that "nothing but" a physiological explanation of thought could be accepted as scientific. This view, which was strenuously combated by many European psychologists, became traditional in American (and Russian) psychological laboratories. Pushed to an extreme, this view resulted in the dogma that learning is "nothing but" a combination of reflex-arc activity explicable through simultaneous excitation of arcs previously isolated. Imagine a schoolroom where this dogma

[4] "Development and Degeneration," H. S. Jennings, Yale University Press, 1934.

was accepted! Undoubtedly, in spite of its actual inapplicability to problems of learning, this dogma has diminished the scientific study of those many other factors in learning which good histories of learning or biographies make evident. Such factors as development of latent powers, insight into the relation between means and end, purposive application, imitation, sympathy, invention and imaginative glow can hardly be ignored by any practical person; but scientific study of these has been discouraged wherever the "older" naturalism prevails, with its arbitrary distinction between the physical facts of nature and the "confused human fancies" concerning them.

The newer naturalism delights in stressing the plurality of factors in learning, to correspond to the plurality of factors in the cosmic process that must be learned.

II

How in the world did it come about that for three centuries (1630–1930) the best minds identified natural science or the knowledge of nature with that type of learning and knowledge which reaches its climax in the laboratory of the physicist? The answer clearly is found in the extraordinary control of nature's resources that learning and knowledge of that type have secured us. Only in our own times has it become apparent to the thoughtful how man's life and purpose is distracted or enfeebled by learning that what for "humanism" is most evident and most significant is for natural science either "epiphenomenal" or "miraculous." This dualism has segregated intelligence into two camps, each so walled in by indifference or contempt for the other that even the interchange of abuse has suffered neglect.

Negatively, the menace of this dualism has been brought home by the inability of either humanism or naturalism of the older type to give an account of man's life that should fill the place in man's imagination and hope that is slowly being vacated by traditions of the supernatural. Positively, however, it is, as Bragg suggests, the work of the historian that has so interwoven the course of nature with the cultural development of mankind that every phase of man's life is now enriched and clarified by recognizing it as the working out of what was implicit in the natural conditions from which man's civilization emerged.

It was the metrical and deterministic emphasis of the older naturalism that compelled the humanists to harbor some sort of supernaturalism. The observation of the historian of nature has compelled the general recognition that qualities and values, individuality and organization play their part in the evolution of natural events, no less than the elements or the mathematical relations exemplified in them. And the multiplicity and distinctness of these several factors in history make not merely incredible but inconceivable the view that the course of nature or of man in nature is determined by one or by all of them.

So, instead of being a mind observing nature from without, or an accident occurring within nature, man to the historian is to-day becoming more and more a revelation of what the propensities of nature are. The antithesis between man and nature, or between nature and anything else whatever becomes increasingly difficult. The new naturalism invites us to lift up our eyes from any special field or method of observation, and in the first place to characterize the concrete events and entities from which all our knowledge is derived.

It is, I think, the peculiar service of

A. N. Whitehead that he has so defined these concrete events that the act of knowing falls under this general definition and so becomes in the fullest sense an event in nature.[5] His account does fullest justice to the "creativity" of nature and of individual entities in nature without succumbing to the mysticism of Bergson. His account of the objects of nature limits their rôle in nature without discrediting at all their actuality or the intelligence which makes these objects known to us.

In the second place, the new naturalism sets itself the task of denoting the several factors abstracted from events that are the theme of as many forms of natural knowledge, such as biology, mathematics and physics. The unity of nature is found not by reducing all factors to one, as in Haeckel's monism, but by showing that each factor implies and is immanent in all the others. This account of the matter disposes of the despairing view that what we know are mere phenomena or "pointer readings" of an unknowable transcendent reality, and makes us feel at home in and with reality itself throughout the adventure of science and knowledge.

It is too early to say whether this newer naturalism will actually stimulate and direct scientific inquiry. It may prove of more value to the scientist than to science. It looks toward an education through which specialists may speak to each other and to the rank and file of mankind with mutual comprehension. It marks the achievement of maturity by that western mind which has too long struggled with the contradictions between oriental dogma and the varied fruits of human experience. These latter now assume for the first time a certain adequacy for the direction of human enterprise toward natural ends.

[5] "Adventures of Ideas," Chapter XI, "Objects and Subjects."

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DUST BETWEEN THE STARS

By Dr. JOEL STEBBINS

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THE question is often asked of the astronomer: How far can you see with your telescope? The answer is simple; one can see the Andromeda nebula with no telescope at all, and that is a million light-years away! Light traveling at the rate of 186,000 miles per second requires a million years to reach us from the nebula, and we now see the nebula as it existed there a million years ago. Put in another way, the flying time at 100 miles per hour for a distance of one light-year is 6,000,000 years; you could fly to the Andromeda nebula in a million times 6,000,000 years. The largest telescope in the world would be capable of photographing this nebula if it were removed to a thousand times its present distance, thus becoming a million times fainter. But the Andromeda nebula is intrinsically one of the largest and brightest in the sky, and we are not sure that any of the more distant nebulae are equal to this one in size or brightness. Therefore, the answer to the question about the present range of telescopes is that objects can be photographed which are more than 100 million light-years but probably less than 1000 million light-years distant.

The Andromeda nebula is one of the so-called galaxies; each galaxy looks to us like a hazy nebula but is made up of many stars. Remember the astronomical multiplication table: It would take a million earths to make one star. A thousand million stars make one galaxy, a thousand million galaxies make one universe. The sun and all the individual stars which we see, mostly in the bright band of the Milky Way, comprise our own galaxy. When we look out at the other galaxies, the question naturally arises: How nearly transparent is the space between us and them? Again the answer is simple. Between the different galaxies space seems to be almost perfectly transparent, but between the stars inside of a galaxy, especially inside of our own, there is good evidence that light is partially absorbed or obstructed. At first thought it might seem impossible to tell whether a star appears faint because it is far away or because some of its light is absorbed or obstructed by dark material in space. If there were no change in the quality of the star's light we could not tell about the obstruction, but if we find that part of the light is missing, as shown by a change in the color of the star, then something must have happened to the light in transit.

We all know how the sun appears more of a yellow or even an orange color when low down than when it is high up in the sky; at sunset it is reddest of all. Amateur photographers know that they must give increased time of exposure to take successful pictures when the sun is low. With a sensitive instrument we could, in theory at least, tell the time of day by measuring the color of the sun, which changes roughly from orange at sunrise to nearly white at noon and then

back to orange again at sunset. This coloration of the sun is due to the air molecules and dust particles which scatter the blue light more than the red, and when we look through an increase of air we see less blue, that is, relatively more red. Similarly, in certain directions in space there are stars which are really white or even bluish white but which appear yellow or red. One difficulty is to distinguish between distant white stars which appear yellow through the dust of space and nearby yellow stars seen in the clear.

Our sun is a typical star with a surface temperature of about 10,000 degrees Fahrenheit; many neighboring stars are equally hot, having the same kind of spectrum as the sun. There are, however, much hotter stars, some of the best examples being in the constellation of Orion. The three stars in the Belt of Orion, which nearly every one knows, and other stars nearby in the constellation have temperatures of 30,000 to 40,000 degrees; they are three times as hot as the sun. These stars are all blue-white in color, and their spectra have characteristic lines which can be recognized wherever found. Because of their high temperatures these so-called Orion stars are much more luminous than the sun; some of them shine with 1,000 to 1,500 times the sun's light, and as they can be seen far off they make convenient standards for estimating distances in space.

Our galaxy of a thousand million stars has often been likened in its shape to a watch, a biscuit or a bun. Imagining ourselves inside of the bun we see stars much farther in the direction of the Milky Way, toward the long diameter of the bun, than out where the bun is flat. The Milky Way extends around the sky and divides the apparent sphere into halves; hence we are in the middle of the bun, between the two slices if it were cut for a sandwich. The most powerful telescope has not yet reached the limit of the faint stars of the Milky Way, but we do see out at right angles to the main plane, and there beyond the stars in the foreground are to be found the other galaxies or nebulae like that of Andromeda. We would see some of these galaxies through the Milky Way were there not so many stars in the foreground.

Now if we consider only the hot and brilliant Orion stars, which we can identify by their spectra, we find that they are distributed all about us. The bright ones are in all directions, but the faint ones tend to follow the line of the Milky Way; the fainter they are the more they are concentrated in the middle band. In other words, the Orion stars outline the form of the flattened galaxy; we see no faint ones at right angles to the Milky Way because the system does not extend so far in that direction.

Next we notice the colors of the Orion stars; the brightest are white or blue-white, the fainter ones are yellow, and the very faint ones near the line of the Milky Way are red. Instead of calling the galaxy a bun we do better to call it a ham sandwich, and we are in the midst of the "ham." Between the stars of the middle layer there is mixed enough dust, so that at great distances through the ham all objects are reddened, but through a thin part of the ham the white stars are given only a slight tinge of yellow.

A few figures on the dimensions of this sandwich may be of interest. The long diameter is about 100,000 light years, while the thickness may be 10,000 light years. The absorbing layer or the ham is relatively quite thin—probably less than 500 light years thick. Roughly the ham may be a tenth as thick as each half of the bun.

The sun with the earth and other planets is not near the middle of the

galaxy, as astronomers thought up to about ten years ago; in fact we are about two thirds of the way out from the center toward one edge. The edge is marked for us not far from the bright stars of Orion. The stars in that part of the Milky Way, those that we see in winter, are not nearly as red as those of the summer Milky Way near the constellation of Sagittarius. From the motions of all kinds of stars it is known that the sun is revolving about a center in Sagittarius, requiring say 250,000,000 years to make the circuit, and it is just in the direction of the galactic center where we find the most interstellar dust, as shown by the reddening of the stars.

Probably some of the audience are interested in how the dust got between the stars in the first place. Is it material left over from the making of the stars, or did it come from eruptions or even blowing up of entire stars themselves? One good answer might be, why worry about the dust until you have found how the stars themselves came to be. It may be noted, however, that sufficiently fine particles of dust are repelled more by the light of a bright star than they are attracted by its gravitation. Once the dust is out in space there is little tendency for it to be collected by the stars.

The total absorption of the light coming to us through the thin part of the cosmic dust layer is about the same as the amount subtracted by the air, 20 per cent., or the absorption of a moderately clean piece of window glass. If you look edgewise through a piece of glass it does not take many feet of it to become quite opaque—and similarly for the edgewise view through the galactic layer of dust; we see a limited distance probably not as far as the galactic center. If you look out at night through a closed window and see the faint hazy speck of the Andromeda nebula, the light which is now affecting your eye traveled a million years with practically no loss, but during the past few hundred years a toll of 20 per cent. has been taken out by the dust in our galaxy; then another 20 per cent. by a few miles of air, and a last 20 per cent. by the window glass. You can get rid of this last third of the veil by going outdoors, and of about half of the effect of the air by climbing up on a mountain, but all the light from the nebula that will come in the next few hundred years is already enmeshed in the dust between the stars of our galaxy.

If you have ever been on a mountain or in an airplane, looking down on the lights of a city, you were perhaps conscious that very little of the life of a man-made community is marked by the lights at the street corners which shine up into the night. For every street light there may be dozen of homes each with its invisible fireside and all the human story that goes with it. So we may think of the stars at the corners of the cosmic streets as outlining the heavenly cities, and we wonder what is between those lights. We have not made many contacts with our celestial neighbors as yet, all we have done is to find a little dust between the stars.

FIVE THOUSAND YEARS OF ENGINEERING

By Dean R. H. FERNALD

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AVAILABLE records indicate that it was only some 5,000 years ago that man first put his ideas into definite form for future generations, using hieroglyphics that to-day we class as one form of writing. Through all these many centuries engineering science has had a profound influence upon the progressive develop-

ment of world civilization. More than five thousand years ago man had progressed sufficiently to make bricks for use with stone in the construction of great temples; to work to scale in making statues and monuments; and to change the entire course of the River Nile that the city of Memphis might be located at a specially desirable spot.

That there was no limit to the magnitude of the undertaking of the rulers of 3 to 5 thousand years ago is evidenced by underground tunnels thousands of feet in length, ventilated by many vertical shafts 6 to 9 feet in diameter; by huge stone temples with columns over 60 feet high and with single stones weighing over 1,500 tons; by canals for conveying merchandise from the inland cities of Egypt to the sea in trade with India, Persia, Greece and Rome.

As a general observation we should note that for the period from 5,000 to 500 years ago, great undertakings were accomplished through the use of hand tools, hordes of slaves and indefinite time, as contrasted with to-day with our refined machine tools, limited numbers of skilled operators and only days instead of years. For illustration, the great pyramid, built over 3,000 years ago, required 100,000 men 20 years for its construction, the huge stones being transported down the River Nile 100 or more miles by raft and a single canal 100 miles long consumed the period of the reign of several rulers before its completion.

During the thousand years preceding the birth of Christ, many great tunnels, sewers and aqueducts were built in Assyria, India, Egypt, Greece and Rome, the remains of which are familiar to many of you to-day. Two especially notable structures of this era were the Appian Way, a Roman road 350 miles long running in a straight course regardless of all obstacles, which was built 300 years B.C. and which was in practically perfect condition for over 800 years; and the Great Wall of China—the largest artificial construction in the world—1,400 miles long, 20 feet high and 15 feet wide at the top, made of stone and brick about 200 B.C. and still of exceptional interest to the traveler in China.

For the period from 500 to 100 years ago we note that, although Leif Ericson discovered America about 1,000 A.D., Columbus rediscovered us some 500 years later and made our continent known to the European world. About this same time the Spanish conquered the Aztecs and found extensive mining galleries. Their tools were made of an alloy of copper and tin. They could carve the hardest metals and with the use of powdered silica could cut quartz, amethyst and even the emerald. Although iron was abundant in the vicinity, they apparently had no knowledge of its use.

Coming now to the time of our grandfathers—only one hundred years ago—we, are amazed by the engineering achievements of their day, of which the following are typical illustrations: The construction of the Suez Canal, which required only ten years for its completion instead of the "reign of ten emperors"; Fulton's steamboat, which revolutionized river and coastwise traffic in this country; and the steam railroad, which was just born, but which by 1840 had several thousand miles under operation in the eastern part of the United States.

The general living conditions of our grandfathers' day were:

Light: Plenty of sunlight by day—no electric light, no gas light, not even kerosene lamps. Only open fires, tallow candles or sperm oil for illumination.

Heat: The fireplace and brick oven for warmth and cooking.

Food: In winter, dried fruits and vegetables,

whole wheat flour and corn meal, simple dairy products and frozen meat from the attic loft.

Clothing: Homemade, mostly from homespun cloth.

Transportation: The horse and sleigh or team and family carriage, perhaps only oxen lumbering along over rough roads with carts with no springs.

Amusements: What the local community could provide.

Hours of Labor: From ten minutes before sunrise to ten minutes after sunset, not the 8- or 6-hour day of 1934.

Accuracy of Work: Instead of measuring to the ten thousandth part of an inch, the degree of accuracy specified was "within the thickness of a worn shilling."

In the Gay Nineties: Imagine American citizens of average means, average tastes, average education, who never rode in an automobile; who never saw an airplane or a movie; who never enjoyed electric lights; who never heard a radio or who never traveled by express elevator to the top of a forty- or sixty-story building. Yet such was the typical citizen of only forty years ago when speed was typified by the bicycle.

To-day we seem to be speed mad. One hundred and twenty-five years ago, the first commercial steamboat did 5½ miles an hour—now the *Mauretania,* the *Leviathan* and the *Savoia;* the 12-mile-an-hour first locomotive to run on rails in America has become the Burlington Zephyr at over 75 miles per hour; and the ill-fated Akron of the U. S. Navy, a Zeppelin type dirigible, was capable of "doing" 90 miles per hour.

The automobile of the nineties required over eleven hours to run a 55-mile race, and the War Department in purchasing cars stipulated that provision be made for attaching mules should the cars refuse to run. To-day our speed is limited only by restricting ordinances and laws.

Engineering and scientific research have brought us man-made silk, rivaling nature's product; solidified gas, which freezes ice cream so hard that we have to warm it before serving. We bounce around on tennis courts with shoes soled with sprayed rubber. We ride on air; we chat with friends on the other side of the world; transmit photographs across the ocean in a few minutes; send checks by radio; metalize paper; write with fountain pens made from sour milk and play poker with chips made from cheese. Due to science and engineering, we live in better homes; we eat better food; we reduce, through modern appliances, the labor of our daily living, and we have for our leisure hours the maximum of entertainment and relaxation.

Mr. Tripp and Mr. Kettering have pointed out that the condition of the common people remained practically stationary for all the thousands of years of recorded history until about 125 years ago. A citizen of Rome traveled to Britain just as quickly in 500 B. C. and by the same means as in 1800 A. D. For 5,000 years transportation was limited to 4 miles per hour or less.

Impassable miles made people prisoners to their own localities. The railroad, the ocean liner, the automobile, the movie, the radio and other modern devices are breaking down the barriers of provincialism and infinitely widening the horizon of the peoples of the world.

The dramatic changes of the past century may in large measure be traced to our greatly increased knowledge, appreciation and use of our vast natural resources of fuels, ores and minerals so essential to the production of power, to the construction of tall buildings, bridges and transportation highways and in the manufacture of all those modern appliances that the well-to-do millions of this country find indispensable in making our lives fuller and happier and which in so many ways make our normal living conditions and opportunities so

far superior to those of most other countries. No other country has been more lavishly blessed with such varied natural resources, and to their consistent development and use may be attributed the strategic position which we occupy among the great powers of the world.

The past 5,000 years have known many periods of depression, many devastating wars, many catastrophes, but after each a new era has been born and the world has come forth into the light of a better day and our brief review of 5,000 years of engineering clearly reveals era after era of progressive development. If from the cycles of the past, we can vision the future we must see before us years of unprecedented prosperity which will call for superior inventive genius, outstanding engineering capacity and aggressive directing foresight.

Our industrial and economic supremacy to-day is due in great measure to three major factors—the universal distribution of energy in the form of power; the development of almost human machines, and the science of management of men.

The future of this country depends largely upon our true accomplishment in the application of the sound principles of management and upon our grasp of the vital essentials affecting the conditions under which the great majority of men must live and work. The opportunity of the ages is before us. The stupendous problems which we are facing at this moment call for the keenest thought, the soundest judgment and unlimited initiative of serious, straight-thinking, scientifically trained men and women.

THE FIGHT AGAINST TERMITES

By C. A. KOFOID

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THINK over the items which entered into your noon meal and see how many of them came from the stored products of the plant world, such as sugar, starch and vegetable oil, and how few, if any, even of the proteins used, came from animals with the power to digest wood. Even the fabled Dutchman's horse, with his economical diet of sawdust, never grew fat on that diet. It is only the termites and a few other insects who have successfully solved the problem of making use of the celluloses as food. This dependence of termites on cellulose as food is the basic cause of the termite problem.

Man's ever-increasing use of lumber in the building industries provides killed wood which is more nutritious than naturally dead wood for termite food. In nature, wood-eating termites depend upon the fallen trees for their food supply. Man immensely increases the amount available, improves its quality, distributes it along his highways and accumulates it in his cities. Thus civilization, with its enlarging use of cellulose, ceaselessly tends to increase the food available for the wood-eating termites.

The domain of these termites is primarily in the tropics and warm-temperate zones. In the United States termites are wide-spread throughout the southern two thirds of the nation, with outlying extensions to the Canadian border.

The termite lives in the dark, apart from the rest of the insect world, and gives but little or no evidence of his presence in the wood. It is only when inter-

nal dry rot and decay have broken down the surface of the wood, or when the building has given way because of accumulating structural weaknesses or when the winged forms swarm, that the presence of the termite becomes manifest. However, in the case of the dry-wood termite, its presence is revealed by the pellets which are extruded from the burrows and gather in heaps on attic floors, or drop out of infested furniture upon the carpet.

Although the termite colony thus lives a secretive life, termites are constantly associated with other organisms of two distinct types on whose presence their very life depends. These are, first, the Protozoa within their digestive tract, which actually digest the wood chips which the termite has gnawed from the surface of its burrows. These microscopic animals extract from the wood some of its food values and make them available as sugars to the termite. Thus the termite itself eats but does not digest the wood. Every kind of wood-eating termite has its own peculiar and highly specialized fauna of Protozoa which distend its gut with a seething mass of these useful messmates.

The wood provides the carbohydrates or fuel for running the termite machine, but not the proteins necessary for growth. Where does the termite get these essential proteins? Undoubtedly he regularly gets a considerable part of the necessary food elements, the beefsteak of his diet, out of a second group of organisms, the fungi which habitually grow in the walls of every termite burrow, spreading there as microscopic, invisible threads. Some of these fungi are responsible for the subsequent decay of wood attacked by termites. Dry rot often follows termite attack. Each kind of wood-eating termite has many different kinds of fungi, including the common bread molds, growing in the wood of his burrows.

There are three major kinds of termites in the United States: the subterranean termites, which work in the soil and creep upward into dwellings; the dry-wood termites, which enter knotholes in trees, checks in poles and crevices in the superstructures of buildings and work down toward the soil; and the damp-wood termites, which favor logs, poles and wood buried in the soil. This third type is confined to the Pacific Coast. The subterranean termites range widely throughout the United States, and the dry-wood termites are confined to the southern states and the southwestern semi-arid region.

Termites live detached from a water supply, but they are delicately sensitive to the humidity of the air in their burrows. They regulate their ventilation and maintain a nearly saturated atmosphere. They habitually seek regions favored by moisture, though they can adapt their modes of life to desert conditions. The subterranean termite in the United States maintains connections with the moist ground, and from the soil enters the basement timbers of dwellings, wherever moisture favors the extension of his burrows.

The termite colony has three typical castes or kinds, with different structures and functions. These are (1) the reproductive pair, called king and queen, the parents of the entire colony; (2) the soldiers, with heavy jaws for fighting, but unfitted for feeding or excavating; and (3) the young or nymphs, which in some kinds of termites are supplemented by a worker caste. The young and workers are doomed to do the drudgery of digging, feeding the soldiers, baby tending, the building of tunnels and towers and keeping the burrows clean and in order. Thus in certain kinds of termites child labor prevails and in others a large slave caste is developed. In all termites an annual crop of winged forms is sent forth from the colony like

propagandists to extend the species into new locations. A brief flight of these alates is followed by pairing and settlement, and digging into the earth or wood to establish a new home. For the whole of the first year the growth of the new colony is very slow. Less than a dozen members are present by the end of that year. The first child born is always a young soldier who is enlisted in military service when half grown.

Elaborate social instincts control the life of this diversified colony. King and queen are fed and groomed by the workers or nymphs, who also tend the young in the early stages; the soldiers kill invading ants and foreigners from other colonies, even of the same species. Upon the workers or young falls all the hard labor of the ordered life of the colony.

The development of a military caste, the exploitation of the young, the limitation and control of the reproductive function, and the substitution of the interests of the colony for the interests of the individual, are all characteristic of the ordered social life of the termites. There are many interesting parallels between the various types of social organization in termite colonies and the efforts at organization in the human hive. In both alike, organization develops at the expense of the freedom of the individual and operates in the interest of the group as a whole. The termite colony is successful because of this organization, but the body of the termite stands very low among insects in structural evolution of the individual.

A termite colony once established is potentially immortal. It can live and extend its burrows as long as it can maintain access to wood. Exploratory tunnels are driven to find new sources of food, and detached outlying groups develop supplementary reproductives and progressively become new colonies on the fringes of the parent group. The subterranean termite in the United States builds covered burrows of a dirt plaster over cement walls, and even up to the second story in buildings. It finds its way through these tunnels to bookshelves, documents in storage and parts of the building remote from one another. Termites select particular pieces of wood in which fungi grow luxuriantly, and reject others, except for mere avenues of transit. You may have heard of the lazy boy in South Africa who left his trousers on the floor, and in the morning found only 10 buttons and a buckle. The termites had devoured the cotton garment.

The death of a king or queen is quickly made good by the development of a supplementary king or queen. But so long as a primary or even a supplementary king or queen in full reproductive function is present in the colony, the development of any additional kings and queens from the full-grown young is inhibited by the secretions of the existing king or queen transmitted to the adolescent young by the grooming habit. The young acquire sexual maturity only after swarming from the parent colony. Thus termites exercise birth control.

This menace of the termite has been the subject of research by a committee representing both science and industry formed at the University of California. The results of this investigation have been published by the University of California Press in a book, "Termites and Termite Control," the second edition of which is now appearing. The proceeds of the sale of this volume are to be used for further research on termites. This book tells how each of the particular kinds of termite must be fought in a way suitable to its habits and its depredations.

The subterranean termite is by habit attached to the ground. A dwelling protected against it should be elevated on concrete or other foundations. Termites burrow through lime mortar, but

not through cement mortar. Foundations should extend at least a foot above the ground, to provide against the termites building tunnels over the cement to reach the wood above. All waste wood should be removed from under and around a dwelling. This includes the lumber in concrete forms, stumps, roots and builders' rubbish. In termite-infested territory chemically treated wood, especially pressure-treated creosoted lumber, should be used as a preventive, or naturally resistant wood with a high extractive may also be used, especially in the basement structures and subfloor. In the case of the dry-wood termite prevention is much more difficult, because of the fact that the winged pairs tend to creep into crevices around openings in the house, under shingles and tile and into cracks or checks in lumber. Thorough painting and the screening of all openings assist in prevention of infestations. Chemically treated wood meets this menace more effectively.

Investigations have shown that all three kinds of termites are generally associated with certain fungi which have the uncanny faculty of utilizing arsenic in feeding, without being killed, in such a way that the highly volatile and very poisonous arsine gas is liberated from arsenic used in treating the soil or in chemically treating wood and wall board as a termite preventive. The Termite Investigations Committee is therefore strongly recommending against the use of arsenic in any form whatever in building materials, wall boards or under and around dwellings as a termite preventive. The reason for the recommendation is the arsenic hazard in fires and the potential danger of the production, by fungi introduced by termites, of the toxic arsine and the slow increase of arsenic in the human body to a toxic or lethal dose by continued inhalation of the arsine.

This fight against the termite is only one phase of the broader problem of man's ceaseless battle with the insect world for the use of the products of the plant world. This contest with the termite will tend to increase with man's ever-widening use of cellulose and the extension of his civilization into the tropics.

SHARK ATTACKS ALONG THE SOUTH CAROLINA COAST

By E. MILBY BURTON
DIRECTOR, THE CHARLESTON MUSEUM

AUTHENTIC published records of persons having been bitten by sharks while in bathing along the Atlantic coast north of Florida are rare; indeed, after exhaustive research, I have found no authentic record excepting an episode off New Jersey in 1916.

Yet, within the last decade, off the coast of South Carolina there have been several well-authenticated cases of fierce attacks upon bathers. I am setting down here some authentic, and what I shall call semi-authentic records of attacks which have occurred off the South Carolina coast in recent years.

On June 21, 1933, 15-year-old Drayton Hastie, of Charleston, S. C., was bathing at the north end of Morris Island, which is situated at the mouth of Charleston Harbor. I am giving an account of the incident in Mr. Hastie's own words:

> . . . Far up the shore line I saw what I thought might be the dorsal fin of a large shark cutting the rough surface. I stood up and strained my eyes to make certain. Yes, it must be a fin, I concluded. . . . Reaching the place and finding nothing that resembled a fin, I believed that I had mistaken a choppy wave for a fin. . . . I did not like the idea of swimming with sharks all around, so I sat down in about three feet of water, at which place the beach sloped gradually until about six feet beyond where I was sitting, at the point it made a deep drop. I was almost certain that in such shallow water I would be safe from anything large enough to bite.
>
> . . . I felt a swerve of water, which was immediately followed by an impact which brought me to my senses. Something clamped down on my right leg. I was aware of a tearing pain up and down my leg, and that I was being pulled outward by something which seemed to have the power of a horse. Looking down, I saw, amid the foam and splashing, the head of a large shark with my knee in its mouth, shaking it as a puppy would shake a stick in attempting to take it away from some one. Through natural instinct, I started kicking frantically with my unharmed leg in order to free myself. I freed my right leg, only to have the monster bite me on my left one. All this time I had been pulling myself up on the beach backwards with my hands and kicking at the rough head of the shark, which seemed to me as solid as Gibraltar.
>
> . . . Although to you this may seem long and strung out, it must have all happened in a space of ten seconds.
>
> . . . Although some people said I had been bitten by everything from crabs up to whales, I still have a perfect design of a shark's mouth around my knee, measuring ten inches across. This confirms the statement of my friend who was standing on the bank and who said that the shark was easily eight feet long.

Mr. Hastie, with much difficulty, was carried to the army hospital at Fort Moultrie, where first aid was administered. It required more than 30 stitches to close the numerous wounds. Later he was transferred to Riverside Infirmary, in Charleston, where he remained a patient for two weeks.

Both the week before and the week after the attack on Mr. Hastie, two eight-foot sharks were taken within one hundred yards from where he had bathed. On identification they were found to be the yellow or cub shark (*Hypoprion brevirostris*), thought to be more a native of the West Indies than of the Atlantic Coast. The only previous record of this shark off Charleston was one small one taken in May, 1882, by Jordan and Gilbert,[1] and another small

[1] *Proc. U. S. Nat. Mus.*, Vol. V, p. 581, 1882.

FIG. 1. PHOTOGRAPHS OF RIGHT LEG OF DRAYTON HASTIE, WHO WAS BITTEN BY A SHARK WHILE SWIMMING OFF COMINGS POINT, MORRIS ISLAND, JUNE, 1933. PHOTOGRAPH TAKEN BY WESLEY JACKSON, JUNE 25, 1934.

one taken by a member of the Charleston Museum staff in October, 1932.

Mr. Lewis Kornahrens was attacked while in the surf at Folly Island on July 31, 1924. Unfortunately, he is no longer in the city and I can get no statement from him. I am quoting from the chart of the Roper Hospital, where he was admitted the day the attack occurred:

> The patient says he was standing in the breakers near the sea-shore in water about waist deep. This was at Folly Beach near the Elks Club. He says something that he thinks was a fish grabbed on both legs at the same time and that he hit the fish (?) with his fist, whereupon it turned him loose. A Negro man came to his assistance and helped him to shore. The patient says the Negro saw about six feet of the fish but didn't stop to observe closely (signed) Dr. J. N. Walsh.

Mr. Kornahrens was treated for "repair of lacerated muscles on the left knee and leg," which required more than 100 stitches, and was discharged on August 28, 1924. Mr. Kornahrens continued to feel a severe pain in his knee cap and it grew steadily worse. Finally he was readmitted to the hospital on November 4, 1924. A minor operation was performed and a fragment of a tooth was taken from the vicinity of the knee cap. His attending physician was Dr. D. L. Maguire, of Charleston. This fragment of tooth is now in the possession of the Charleston Museum (*Spec. 2811*). Recently it was sent on for identification to Drs. Gudger and Nichols of the American Museum of Natural History of New York, and the following is quoted from a letter from Dr. Gudger, dated July 13, 1933:

> I am returning under separate cover today the tooth fragment you sent. This is not a barracuda tooth. There is no doubt on this point. Mr. Nichols and I are both satisfied that it is a fragment of a shark's tooth, and we are inclined to think that it is from one of the mackerel sharks, but presumably a young specimen.

Young Kenneth Layton and a friend were in bathing at Pawley's Island, which is about seventy-five miles north of Charleston, when they were startled by a cry of "Shark! Shark!" from a man standing on the beach.

At the place where they were bathing, the beach is very flat; consequently, they were well out from shore, although in water not much over four feet. Both he and his friend were terribly startled when they heard the cry of warning. Looking down the beach, they saw a large dorsal fin of a shark 50 yards away. They immediately rushed for shore. Layton says the shark deliberately tried to cut them off. When they reached water about waist deep, Layton was seized by the right heel and ankle. He struggled frantically, and in the meanwhile his friends who were bathing nearby were rushing to his assistance. Together with his struggle and the commotion caused by the approach of his friends, the shark was frightened to such an extent that it relinquished its hold.

Young Layton was rushed to the

Riverside Infirmary at Charleston, where it was ascertained that several tendons in his leg, including the Achilles, had been severed. His attending physician was Dr. A. Johnston Buist, of Charleston, S. C., who states that the patient has completely recovered the use of his foot. This attack occurred on August 28, 1933. The information regarding the attack was furnished me by Layton himself.

Mr. C. B. Hernandez tells me that in July, 1907 or '08, while swimming in a small creek about 15 feet deep, back of Coles Island, he was suddenly attacked by a shark. At the time, he was floating on his back. When the shark grabbed hold of his left knee, it apparently did not get a firm grip, but immediately attacked him again, getting a much firmer hold on the lower part of his leg. Mr. Hernandez says hardly a second elapsed between the first and second attack. He immediately floundered over and fought off the shark, which he saw quite clearly at the time. Apparently the shark was frightened away, because, though bleeding freely, he was not molested again as he swam back to the dock. Mr. Charles Millikan was standing at the head of the wharf when the attack occurred and clearly saw the shark. Both he and Mr. Fernandez estimated it to be about five feet in length. The scars on Mr. Hernandez' left leg are in crescentic form.

Mr. W. E. Davis, while swimming in James Island Sound, was viciously attacked by a shark. Mr. Davis is a member of the Officers Reserve Corps, and has recently been called into active service and is stationed at one of the C. C. C. Camps at White Springs, Florida. I have received a letter from him and am quoting from it in part:

> On this particular afternoon, the tide was extremely high, even for a spring tide. So high, in fact, that it lacked less than an inch of covering the bridge. It was a perfectly calm afternoon with barely a ripple on the water. Following my custom I dove from the wharf and headed out into the sound. I had swam probably thirty yards when my left foot was seized. Due to the water I was conscious of no pain, only pressure. My instant and involuntary reaction was to jerk practically clear of the water, and due to the sharpness of the teeth holding me I succeeded in ripping my foot clear. I immediately turned around and headed for the bridge. As I did so I saw directly in front a swirling of the water and at the same time the white of a shark's stomach and the tip of its tail. Unthinkingly, in my haste to regain the wharf, I swam directly over this spot and in so doing experienced a sharp burning contact with some rough-skinned body. Fortunately I reached the wharf very shortly. I was pretty well knocked out but did notice that my foot was practically mangled from about five inches up the leg down. Also a raw spot where the rough skin had touched me. The lacerations on my foot continued out in cleanly defined cuts to the tips of my toes, indicating that the shark had really held on to the last.
>
> . . . It must have been a vicious fish and an intentional attack because I had no warning whatsoever. Further, the water that afternoon was exceptionally clear so that the shark could not have been mistaken as to what it was attacking. Also I was swimming vigorously and making quite a commotion in the water. Under the conditions I think it was a hungry, vicious shark that intentionally attacked me, and had

FIG. 2. PHOTOGRAPHS SHOWING RIGHT LEG OF MISS EMMA G. MEGGINSON WHO WAS BITTEN BY A SHARK(?) WHILE SWIMMING OFF FOLLY ISLAND, JUNE 16, 1933.

I been further out in the sound would have attacked me again.

When Mr. Davis was taken to the St. Francis Xavier Hospital in Charleston, it was at first thought that his foot would have to be amputated. Fortunately, this did not have to be done, and Mr. Davis regained the full use of it, although it required 70 odd stitches to close the lacerations. His attending physician was Dr. Robert Catheart, of Charleston. This attack occurred on May 29, 1919.

These five cases, I feel, are absolutely authentic. The succeeding cases which I shall outline come under the category of semi-authentic, as no one actually *saw* the shark.

Mrs. Walter K. Kahrs and her husband were bathing at Folly Island on August 2, 1925. They had waded out until the water was about waist deep, Mrs. Kahrs in advance of her husband. They had both dived through the first line of breakers and were swimming steadily outwards, when Mrs. Kahrs was suddenly attacked. She screamed frantically and fought off the shark (?). Meanwhile, her husband, who had been swimming about ten feet behind her, rushed to her aid. Between the commotion of both of them the shark (?) was scared away.

Mrs. Kahrs was rushed to the Riverside Infirmary at Charleston, where it was found she suffered "multiple lacerations on both thighs, right buttock and hip." It required 78 stitches to close the numerous cuts and gashes. Her attending physician was Dr. John LaRoche, of Charleston.

Mrs. Kahrs tells me she was so frightened that she has no clear conception of what really happened. She was simply conscious of a sudden attack by some very large object. She thinks she struck the fish in her struggle, but is not perfectly certain about it. She also tells me some of her scars are in the shape of a half-moon.

Miss Emma G. Megginson was standing in the surf in water about waist deep, when she felt something pinch the calf of her left leg, but thought it was her younger brother playfully grabbing at her. In another moment she felt a much more savage attack and then saw blood come to the surface of the water. She rushed out of the surf, and found she was bleeding freely from numerous cuts. She was taken to the Roper Hospital at Charleston, where it required 36 stitches to close the wounds.

Miss Megginson tells me she saw what was apparently the back of the fish and estimates it as being about a foot wide and black. She very kindly consented to let me have a photograph taken of her scars. The attack occurred at Folly Island on June 16, 1933. Her attending physician was Dr. G. F. Heidt.

I have endeavored to track down rumors of several other attacks that have been reported from time to time. But invariably they either happened many years ago, the victim and witnesses are dead or have moved away or a person has drowned under unusual circumstances. The information has been so meager in all the cases that I feel that it can not even be placed in a semi-authentic classification.

Invariably when an attack of this kind occurs every one immediately concludes, "barracuda." In many respects this is quite understandable, as the psychological effect would be extremely bad and no one would frequent the bathing beaches. In fact, last summer immediately after the attacks on Miss Megginson and Mr. Hastie, there was a marked decrease for quite a time in the number of bathers. The great barracuda (*Sphyreana barracuda*) is apparently very rare in and around Charleston. There is a skull of a fairly large specimen in the Charleston Museum, labeled

"off Charleston Harbor, 1874." That appears to be the only authentic record. Occasionally the small northern species (*Sphyraena borealis*) is caught, but that, too, is apparently quite rare. For the last five years the museum has been trying to secure a specimen for its collection, but has been unsuccessful so far.

For any one wishing further information on these various cases, I will be only too glad to make appointments for them with the following: Messrs. Hastie, Layton, Hernandez, Mrs. Kahrs and Miss Megginson, Drs. Buist, LaRoche, Catheart, Heidt and Maguire; and I feel sure, for any one sufficiently interested, I can get permission from the hospital authorities for him to go over the charts and records of the various cases.

There are records of the following sharks[2] having been taken in and around Charleston:

Nurse Shark (*Ginglymostoma cirratum*). Occasionally taken during the warmer months.

Dog-Fish (*Mustelus canis*). Two records, one seen by Jordan and Gilbert in 1882 (Proc. U. S. Nat. Mus. 1882, Vol. V, p. 581), and the second one brought in last winter by a trawler.

Tiger Shark (*Galeocerdo tigrinus*). A 42-inch specimen brought in during December, 1932. Taken by a fisherman about twelve miles off shore. This shark was totally unknown to the fishermen and longshoremen, showing that it must be extremely rare. This is the first authentic record of its ever having been taken off the South Carolina coast.

Sharp-Nosed Shark (*Scoliodon terraenovae*). The most abundant of our sharks and the bane of the fishermen. Never seem to reach a large size.

Ground Shark (*Carcharhinus commersonii*). Moderately abundant during the warmer months.

Black-Fin Shark (*Carcharhinus limbatus*). Extremely abundant during the warmer months. Apparently follows the shrimp trawlers in large schools. I know of a case where as many as nineteen were taken from under a trawler in a comparatively short space of time. Very few specimens exceed five feet in length.

Yellow or Cub Shark (*Hypoprion brevirostris*). Only four authentic records, but possibly more common than generally thought.

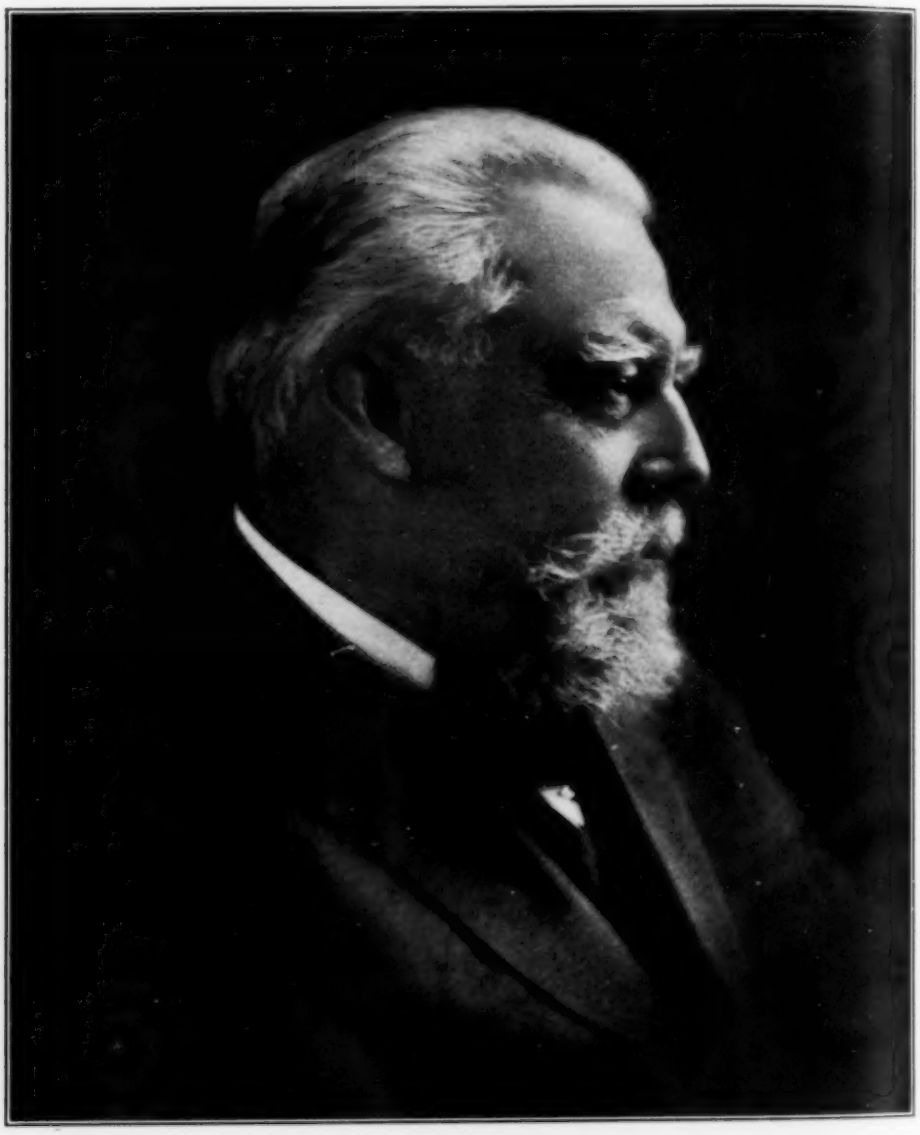
Shovel-Nosed Shark (*Sphyrna tiburo*). Common during the warmer months.

Hammer-Head Shark (*Sphyrna zygaena*). This is also a moderately common species during the summer months.

Sand Shark (*Carcharias littoralis*). One of the most common of our large sharks. Capt. William Magwood, of the shrimp trawler *Geneva Moore*, caught six, ranging in length from 8½ feet to 9½ feet, in a single haul of the net. Large specimens are frequently brought in by the trawlers during the summer months.

Mackerel Shark (*Isurus punctatus*). The only authentic record is a drawing made by Dr. Edmund Ravenel in 1821 from one brought in from off shore. The identification was made by Henry W. Fowler, of the Academy of Natural Sciences of Philadelphia. It is interesting to note that Dr. Ravenel was a close friend of the celebrated ichthyologist, Dr. John Edward Holbrook.

[2] Am using the word shark in the generally accepted sense of the word, and am not dividing them into various families.



THOMAS HUSTON MACBRIDE

THE PROGRESS OF SCIENCE

THOMAS HUSTON MACBRIDE, AN APPRECIATION

In his gradual development from a field naturalist, interested in many different phases of natural science, to a specialist in a limited field, Thomas H. Macbride illustrates in his life the tendencies of science during the more than six decades of his scientific activity. Born in eastern Tennessee, the oldest son of a Presbyterian minister, he was brought to Iowa in a wagon at the age of six, his father's ardent advocacy of the abolition of slavery having made it desirable for the family to find a home in free territory. Educated at Lenox and Monmouth colleges, after his graduation he was for eight years an instructor in mathematics and modern languages in the former institution, and at the same time an ardent amateur naturalist. His introduction to natural science was through Samuel Calvin, one of his early teachers at Lenox, and the association there begun continued without interruption until the latter's death in 1911. In 1874 Calvin was called to the University of Iowa as professor of natural philosophy, and when, four years later, he found the multitudinous duties of such a chair growing beyond his capacity to handle them alone, he secured Macbride as his coworker, as assistant professor of natural science. As such, he taught botany, geology and zoology. Then, when geology became a separate department, Macbride was made professor of botany and systematic zoology, and finally, in 1889, professor of botany. Shortly thereafter he went abroad, spending six months in Strasburger's laboratory at Bonn. Upon his return, he was one of the first to introduce to American students the new methods and view-points there developed. In 1914 he was elected president of the university, but found administrative work little to his taste and in 1916 he retired, to devote himself to his special studies and to answer the many calls made upon him as the first citizen of Iowa. In his last years he spent much of his time in Seattle, and there he died on March 27, 1934.

His scholastic career is paralleled by his publications. His first paper seems to have been zoological and many of his earlier writings were in the field of geology; in fact, he retained an active interest in geology long after his teaching of the subject had ceased. He was the author of several reports on the geology of Iowa counties, the last of which appeared in 1905, and a paper on paleobotany was issued in 1907. But botanical topics occupied his attention increasingly. At first general, these became more and more specialized, first in the fungi, and then in the more restricted field of the slime molds, upon which group he became recognized as the leading American authority.

In his early days he was greatly influenced by his field trips, often taken in company with Dr. Calvin, and when he came to the university, these trips were continued, especially in the summer, when it was possible to go farther afield. On one such trip to the Black Hills, he and Calvin discovered the remarkable fossil cycads of that region, and with much labor and considerable expense, brought a number of fine specimens to the university, where they still remain. Later, he visited the Yosemite, New Mexico, Southern California and Washington, and his collections of slime molds from these regions constitute an important part of the Myxomycete collection at the university, largely built up by his efforts and unexcelled in the western hemisphere.

He had an unusual capacity for arousing the interest and affection of his students and for imparting to them something of his own enthusiasm for nature. But his interests went far beyond the

classroom. He was one of the earliest advocates of conservation. A paper urging the establishment of parks in each county appeared in 1895, and in 1901 he was the first president of the Iowa Park and Forestry Association. One outcome of this interest in the preservation of natural conditions and in the study of plants and animals in their native surroundings was the establishment of the Iowa Lakeside Laboratory in 1909. His work for conservation is fittingly commemorated in the name of the Lake Macbride State Park, recently established near Iowa City.

He never sought honors, but when they came to him in the natural course of events, he accepted them and such responsibilities as they entailed with modesty and cheerfulness. In 1897 he was made president of the Iowa Academy; in 1903 he was vice-president and chairman of Section G of the American Association; he was the holder of several honorary degrees. More important than these, however, is the tradition of industry, wide scholarship, kindliness and courtesy which he has bequeathed to his successors in the department he founded and to the university and commonwealth he served. Such traditions accumulate slowly, for the men who can establish them are rare, but for all their intangible nature, they come to be recognized as the most precious heritage any university may possess.

G. W. Martin

Department of Botany
University of Iowa

PROFESSOR EDWARD BARTOW, PRESIDENT-ELECT OF THE AMERICAN CHEMICAL SOCIETY

Professor Edward Bartow has had the career of an unusually successful professor and head of a department of chemistry in the Middle West. Next year he will become the president of the American Chemical Society, which has 17,000 members and an annual budget of $440,000.

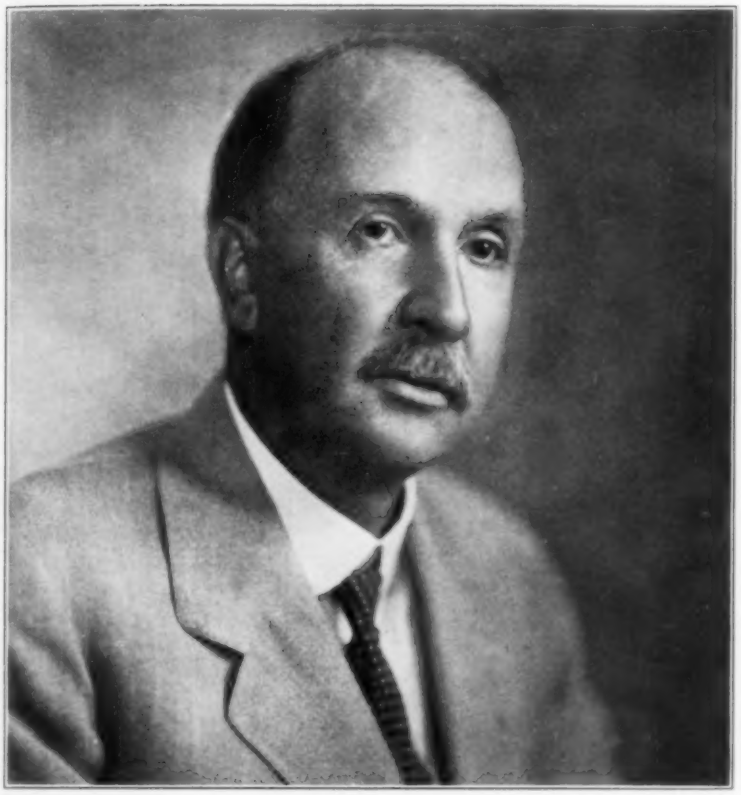
Professor Bartow was born in 1870 in a small village near Fishkill, New York, and prepared for college in a private academy at Fishkill. He graduated at Williams College in 1892 and took his doctor's degree at Göttingen in 1895. After two years as an instructor in Williams College he spent eight years at the University of Kansas and was then called to the University of Illinois as director of the State Water Survey, which had been founded by Professor A. W. Palmer. He was at the same time associate professor for a year and then professor of sanitary chemistry.

Many men who received their training under him from 1905 to 1917, eighty or more officers who worked under his direction in France and many who have graduated from the State University of Iowa are now scattered over the country in responsible positions, as professors, directors of water works laboratories, chemists caring for the wastes of industrial plants and in other occupations farther afield from their special training. It is in no small measure the splendid loyalty of these men which has led to his selection as president-elect of the American Chemical Society—the greatest honor in the gift of American chemists.

During his first years as director of the Illiniois State Water Survey, the first organization of its kind in the Mid-West, he was a leader in the campaign to combat epidemics of typhoid fever by the introduction of pure municipal water supplies.

In 1914, while in England, he became acquainted with the recently discovered activated sludge process for the treatment of sewage. After returning to Urbana he spent several years in studying and developing this process. He secured its introduction in Milwaukee and it is now used in Chicago, Indianapolis and in many other cities.

When air in small bubbles is passed



PROFESSOR EDWARD BARTOW

through raw sewage for from one to three weeks, aerobic bacteria slowly increase and an activated sludge will settle out on standing for a short time, leaving clear water from which 90 per cent. of the organic matter has been removed and which can be discharged into a river or lake without offensive pollution of the water. With "activated sludge" produced in this way new portions of sewage may be purified in from six to twelve hours. As the apparatus is less expensive and requires only 10 per cent. of the area needed for trickling filters, the only other method then in practical use on a large scale, the economic saving due to the method is enormous.

In 1917, soon after the United States entered the war, Professor Bartow was commissioned as major in the army and went to France to care for sanitary work and especially for water supplies for our expeditionary forces. Later he was commissioned lieutenant-colonel. With a large staff of able assistants he not only directed sanitary work for men in the field but also rendered notable service by calling the attention of European chemists to the use of liquid chlorine in purifying water supplies.

While in France his delightful personal qualities secured for him a host of French, English and American friends and it is doubtful if any other American chemist has such a broad and worthwhile acquaintance.

Soon after his return from France Professor Bartow was appointed head of the department of chemistry and chemical engineering at the State University of Iowa. Since he went there the department has had a rapid growth, espe-

cially in the field of graduate work, and a very fine new chemical laboratory has been built.

Professor Bartow has received many honors. He was awarded the *Medaille d' Honneur* by the French Government, and at Madrid last summer he was chosen vice-president of the International Union for the United States and made a corresponding member of the Spanish Academy of Sciences. He was given the honorary degree of D.Sc. by Williams College in 1923.

W. A. NOYES

EMERITUS DIRECTOR
THE CHEMICAL LABORATORY
UNIVERSITY OF ILLINOIS

AWARD OF THE PERKIN MEDAL TO DR. GEORGE O. CURME, JR.

ON the evening of Saturday, October 6, 1906, a banquet at Delmonico's, New York, with Sir William Henry Perkin as the guest of honor, brought to a fitting close the American celebration of the Perkin Jubilee, for it was in the Easter vacation of 1856 that Perkin's discovery of the "mauve dye" laid the foundation for what rapidly grew into the vast coal tar dye industry.

In commemoration of the occasion, a Perkin Medal was established, to be "awarded annually for the most valuable work in applied chemistry," and the first medal was presented to Sir William himself.

To an American industrial chemist, no higher distinction can come than the award of this medal, for the jury of award is made up of representatives of the American Chemical Society, the Electrochemical Society and the American Institute of Chemical Engineers, as well as the American Sections of the Society of Chemical Industry and of the Société de chimie industrielle, and the list of medalists is indeed a roll of honor comprising those who have been great builders of American chemical industry.

The jury selected Dr. George O. Curme, Jr., for the 1935 award because he too has been a founder of a new and rapidly expanding industry, namely, that of synthetic aliphatic organic chemistry based upon petroleum as initial material, and it is entirely possible that the development of this new petroleum chemistry during the next fifty years may rival or even excel that of the past fifty in coal tar chemistry. In fact, the successful commercial synthesis of ordinary ethyl alcohol seems as noteworthy

THE FIRST PERKIN MEDAL
WHICH WAS AWARDED TO SIR WILLIAM HENRY PERKIN FOR HIS DISCOVERY OF THE "MAUVE DYE" IN 1906.

THE AWARD OF THE PERKIN MEDAL

PROFESSOR MARSTON T. BOGERT, OF COLUMBIA UNIVERSITY, PAST-PRESIDENT OF THE SOCIETY OF CHEMICAL INDUSTRY, PRESENTING THE MEDAL TO DR. GEORGE O. CURME, JR.

an industrial accomplishment in this field as that of synthetic indigo was in the dye field.

For decades coal tar was used only as roofing material, for road building, briquetting coal dust, and the like, before it was discovered that by distillation it could be made to yield a great variety of useful products, from which in turn new industries rapidly grew. This history is being repeated in the case of petroleum. At first used mainly for lubricants and illuminants, it was soon found that even for these uses its value could be greatly enhanced by suitable heat treatment. But these processes were chiefly engineering problems, and the industry exhibited little or no interest in what the synthetic organic chemist might contribute.

It was Dr. Curme who, some twenty years ago, recognized this situation clearly and envisioned its possibilities.

Starting with simple hydrocarbons obtained by the "cracking" of petroleum fractions, he has demonstrated how there can be prepared therefrom, on a commercially profitable basis, in part by wholly novel processes, such interesting compounds as ethylene chloride, ethylene glycol, ethylene chlorohydrin, ethylene oxide, dichloroethyl ether, various alcohols, aldehydes and ketones, acetic acid and its derivatives, and such new products as carbitol, butyl carbitol, methyl and butyl cellosolves, pyrofax, vinylite resins, and many others.

Prior to the world war, we were recognized leaders in the manufacture of inorganic and "heavy chemicals," but were dependent upon Europe for most of our organic chemicals, and this deficiency crippled us severely during that conflict. Since then we have succeeded in building up some of our organic chemical industries, like the dye industry, for ex-

ample; but it has remained for Dr. Curme and his associates to bring to us the leadership in that vast and far-flung domain of synthetic aliphatic chemistry based upon a raw material, petroleum, with which we are so richly endowed.

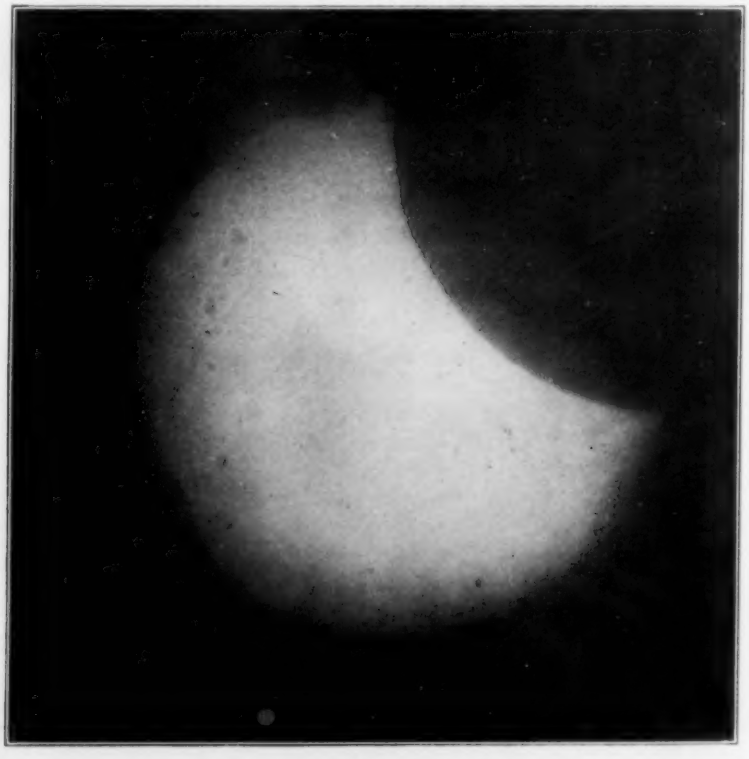
Curme's work has had a stimulating effect also upon university departments of chemistry and has increased the demand for competent and well-trained synthetic organic chemists. In war, as well as in peace, an adequate supply of such experts is of immense importance, as they know particularly well who have had experience in the Chemical Warfare Service or the Ordnance Department.

Dr. Curme is vice-president and director of research of the Carbide and Carbon Chemicals Corporation, and in 1932 received the Chandler Medal of Columbia University, which is awarded annually "to the chemist whose research work, in its commercial application, has done most to advance industry."

MARSTON TAYLOR BOGERT
PROFESSOR OF ORGANIC CHEMISTRY
COLUMBIA UNIVERSITY

THE FEBRUARY SOLAR ECLIPSE

SWEEPING over North America with its usual astronomical precision, the moon's penumbra raced across a large part of this country on February 3, partly dimming the light of day. In New York two fifths of the sun was obscured at 11:31 A.M. However, the greater part of the land suffered from being covered with heavy clouds, so that relatively few observers were favored with a view,



THE SOLAR ECLIPSE OF FEBRUARY 3
A PHOTOGRAPH TAKEN AT THE HARVARD OBSERVATORY AT 11:15 A. M. (EASTERN STANDARD TIME).

—Courtesy of The American Museum of Natural History

DIAGRAM OF THE APPROXIMATE EXTENT OF THE PENUMBRA FALLING ON NORTH AMERICA AT 11:00 A. M. (EASTERN STANDARD TIME), ON FEBRUARY 3. THE SHADOW AREA WAS MOVING NORTHEAST AT THE RATE OF ABOUT 1,600 MILES PER HOUR WITH THE AXIS TURNING IN A CLOCKWISE DIRECTION. AT THE BEGINNING AND END OF THE ECLIPSE THE SHADOW WAS MUCH SMALLER THAN SHOWN HERE.

although seemingly there was a high degree of popular interest in the event. (One of the largest cities where success was attained was St. Louis, Mo.) As if to make up for the disappointment, the moon on the evening of the following day shone above the clear horizon just after sunset as an exceedingly thin crescent, with the *earthshine* lighting up the entire dark side of the moon, and alongside, forming a straight line with it, were Mercury and Venus, the three celestial objects offering a magnificent sight.

Astronomically these partial eclipses of the sun are quite unimportant, for almost none of the features take place that occur with total eclipses. Probably the most valuable observations to make at partial eclipse times involve getting the "contacts" or exact instants of beginning and ending. The timing furnishes a check to part of the refined computations necessary in this type of work. Sometimes an eclipse is a second or two ahead of its schedule, sometimes a second behind; these discrepancies must be explained by the professional astronomer. One must have a telescope, a watch and access to the correct time. The error of the watch is found before and after the eclipse, so that the true

mean solar time is known to a quarter-second.

The eclipse was not total at any place on earth—there is no total eclipse this year, except on other planets, where they may be everyday affairs. But the sun and moon went through the same performance as at the time of totality, only the earth was not in place. That is to say, the umbra or complete shadow was there, as it always is, but was falling in space and missing the surface of our globe by miles. Had we ascended into the stratosphere or above, at the right place above this continent, we could have had the full benefit of totality, or at least of an annular eclipse, according to circumstances of the moon's distance from the earth, and the earth's distance from the sun. If totality took place, then from this unique position we would have been impressed with the superb color effects of the corona, prominences and chromosphere, and with an intense black sky, brilliant stars without a sparkle, and meteors flying by—dark and cold if above the earth's atmosphere—all to be witnessed in the daytime.

On the surface only the outer shadow of the moon struck the earth, and it first touched the globe off the coast of Lower California. This shadow was tangent to the earth's surface at this point at sunrise. It then raced across the country at about 1,600 miles an hour, covering the entire United States and most of Canada, and leaving the surface near the southeast coast of Greenland at sunset, when it was again tangent to the surface of our planet.

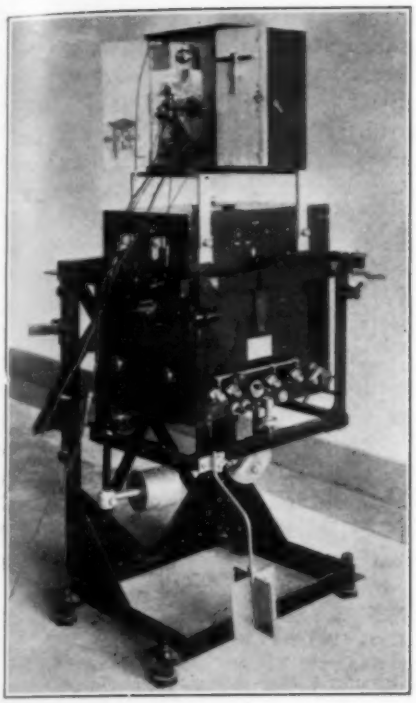
In 1935 we have seven eclipses (the greatest possible number), the remaining ones being: on June 30, a partial eclipse of the sun, that travels across the north pole; on July 16, a total eclipse of the moon, visible fortunately from most of North America; another partial eclipse of the sun on July 30, between South Africa and Antarctica; and on December 25, an annular eclipse of the sun in Antarctica, the central line going within 2° of latitude of the south pole. Next year, there will not be any eclipse visible in North America.

CLYDE FISHER AND HUGH S. RICE
AMERICAN MUSEUM
OF NATURAL HISTORY

THE GRAVITY-AT-SEA EXPEDITION

ON November 14, 1934, Dr. F. A. Vening Meinesz, of the Netherlands Geodetic Commission, left Holland on a submarine of the Dutch Navy on his eleventh expedition for the determination of gravity at sea. The observations will be made in the Atlantic and Indian Oceans. According to an itinerary received from Dr. Meinesz, he will cross the Atlantic twice on this expedition, once close to the Equator and once in the South Atlantic. He will then cross the Indian Ocean from South Africa to Australia and from there will proceed to Java. Among the ports at which the submarine will stop for refueling and to give much-needed rest to the personnel are Funchal, Dakar, Pernambuco, Buenos Aires, Capetown, Mauritius and Freemantle. Altogether the expedition will take about eight months from the times it leaves Holland until it reaches Java.

With the exception of the expedition from Holland to Java by way of the Panama Canal, made by Dr. Meinesz in 1926, the present one is the most extensive and one of the most important of the many expeditions for determining gravity at sea with modern accuracy. It will furnish much-needed gravity data in the Southern Hemisphere, and it will contribute toward a general gravimetric survey of the Atlantic Ocean which is needed in geophysical and geological studies of that area.

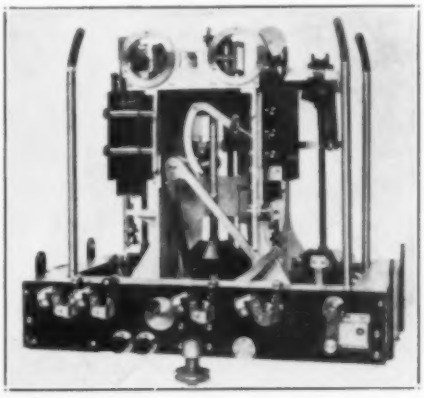


MEINESZ GRAVITY-AT-SEA APPARATUS
THE LARGER BOX CONTAINS THE PENDULUMS, THE UPPER AND SMALLER BOX THE PHOTOGRAPHIC RECORDING DEVICE. THEY ARE SUPPORTED IN GIMBALS, FOR EVEN AT A DEPTH OF 10 FATHOMS THE SUBMARINE IS STILL SOMEWHAT AFFECTED BY WAVE MOTION.

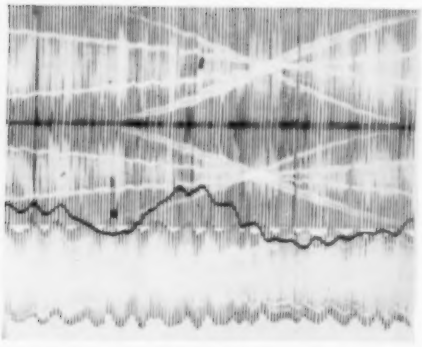
A very large proportion of all the gravity determinations in the world have been made in the Northern Hemisphere and, except in the East Indies, where Dr. Meinesz made an intensive gravimetric survey of the water areas a few years ago, most of these determinations are north of the Torrid Zone. The need for more work in the Southern Hemisphere, both on land and at sea, has long been realized. The International Association of Geodesy has called on the scientific organizations of the different countries to do everything possible to overcome this lack of data as rapidly as possible. England and The Netherlands have responded to this appeal; England by sending a gravity party to East Africa, and Holland by financing the present expedition.

The new gravity measurements in the Atlantic Ocean will be of special interest for several reasons. First, they should be of help in indicating whether or not a longitude term is needed in the formula which denotes the change of gravity over the sea-level surface of the earth; second, they will help more nearly to fill the gap in gravity values between the Eastern and Western Hemispheres; and third, they should throw some light on the formation of the mid-Atlantic ridge from the standpoint of isostatic equilibrium. This gravimetric survey of the Atlantic will undoubtedly indicate critical areas where it will be desirable to carry on intensive surveys.

Other countries of the world beside The Netherlands should take an active part in making the detailed surveys that may be needed in this area. The United States Navy in cooperation with other organizations in this country and with the assistance of Dr. Meinesz has done valuable gravity-at-sea work in the West Indies. It is hoped and expected that



INSIDE VIEW OF MEINESZ APPARATUS
THE RECORDING IS DONE IN SUCH A MANNER THAT TWO PENDULUMS SWINGING IN OPPOSITE PHASE ARE COMBINED TO GIVE A THEORETICAL PENDULUM WHICH IS NOT AFFECTED BY THE SLIGHT HORIZONTAL ACCELERATIONS OF THE SUBMARINE.



SECTION OF RECORD

MADE BY MEINESZ APPARATUS. IT SHOWS THE OSCILLATIONS OF TWO THEORETICAL AND ONE REAL PENDULUM, THE SECOND-TICKS OF TWO CHRONOMETERS, THE TEMPERATURE OF THE AIR WITHIN THE PENDULUM CASE AND THE ENDWISE TILT OF THE PLANES ON WHICH THE PENDULUMS SWING.

they will undertake more work of this kind in the future. Italy and France have made a number of determinations in the Mediterranean Sea. Geophysicists in many other countries are fully aware of the importance of determining gravity over the great water areas of the world, and are urging their navies to undertake this valuable peace-time work.

At present, gravity-at-sea determinations are not practicable except on a submarine, which must be submerged deep enough to be only slightly affected by wave motion. The cost of doing the gravity work at sea involves only that for fuel and the salaries and traveling expenses of the observers, other than the pay of the officers and the members of the crew, which goes on whether the ship is at the dock or at sea. Dr. Meinesz and the Netherlands Navy have blazed the trail. Others should help them in this great undertaking of determining gravity over the oceans.

C. H. SWICK

U. S. COAST AND GEODETIC SURVEY